New Hampshire Volunteer Lake Assessment Program

2014
Merrimack Valley
Regional Report

Powwow Pond, East Kingston

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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New Hampshire
Volunteer Lake Assessment Program
2014 Merrimack Valley Regional Report

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REGIONAL HIGHLIGHTS

- The Merrimack Valley Region (MV) consists of those towns in New Hampshire's *Hillsborough County*, western portions of *Rockingham County*, and southern portions of *Merrimack County.*

- Regional freshwater recreation, including boating, fishing and swimming, in the MV Region generates approximately **$44 million dollars in sales, $16 million in household income, and 704 jobs annually** (Nordstrom, 2007).

- **A perceived decline in water quality** as measured by water clarity, aesthetic beauty, or overuse could result in approximately **$19.5 million dollars in lost revenue, $7 million in lost household income and 306 lost jobs** (Nordstrom, 2007).

- Regional population is expected to grow by **115,000 people in Hillsborough, Rockingham and Merrimack counties by 2030**. The majority of growth is estimated to occur in the towns of Goffstown, Manchester, Bedford, Merrimack, Litchfield, Nashua, Hudson, Pelham, Salem, Windham, Derry, and Londonderry.

- The MV region is home to over **18,000 acres** of lakes, river, and wetlands. Over **7,000 acres or 40 percent** of water occurs in the towns predicted to experience the most population growth.

- The regional average summer air temperature was 1.8° F above the historical regional average conditions in 2013 and 1.1° F above average in 2014, as reported in Manchester, N.H. Regional average surface water temperatures were approximately equal to the historical regional average, as recorded by VLAP, in 2013 and 1.0° F cooler in 2014. Regional average summer precipitation (rainfall) was 2.0 inches above the historical regional average in 2013 and 0.80 inches above average in 2014.

- The MV region consists of **142 lakes** or great ponds. Regional water quality data is collected at **24 lakes participating in VLAP** while the **remaining 80 percent of lakes are sparsely monitored** through the NHDES Lake Trophic Survey Program.

- Regional lakes are classified into three categories that describe the overall health of the lake as oligotrophic, mesotrophic, or eutrophic by the Lake Trophic Survey Program. Seven lakes are oligotrophic, 54 are mesotrophic, 34 are eutrophic, and 41 are un-assessed for trophic classification due to lack of data. Two oligotrophic, 15 mesotrophic, and seven eutrophic lakes participate in VLAP.

- VLAP lakes are monitored at the deepest point in the lake and at streams entering or exiting the lake. Lakes are monitored monthly during the summer season to establish baseline water quality data and discern long term water quality trends that provide information on overall waterbody health.

- Regional trend analysis performed on historical water quality data found no significant trend for parameters chlorophyll-a, chloride and total phosphorus. Acid neutralizing capacity (ANC) significantly increased, which indicates improving conditions. Epilimnetic turbidity and conductivity significantly increased, and transparency and epilimnetic pH significantly decreased, which indicates declining conditions.

MERRIMACK VALLEY REGION WATER QUALITY INDICATORS

The following describes the water quality indicator measured through VLAP, the regional trend that was detected and the current status of the indicator. Trends were determined with a non-parametric Mann-Kendall trend test of the annual medians for each parameter.

Exotic Species	Chlorophyll-a	Transparency	Phosphorus	Dissolved Oxygen	pH	Conductivity	Chloride	Turbidity

Indicator	Trend	Description
Exotic Species	N/A	Twenty-four waterbodies in the MV region are infested with an exotic species. One new Variable milfoil infestation was discovered in 2014 at Beaver Lake in Derry and another in 2015 at Pine Island Pond in Manchester. Twenty-one waterbodies are infested with Variable milfoil, nine are infested with Fanwort, one is infested with Brazilian elodea, and the Nashua River also has Water chestnut, European naiad, Variable milfoil, Eurasian water milfoil and Curly-leaf Pondweed infestations. Many waterbodies have multiple infestations including Massabesic Lake, Mine Falls Pond, Nashua River, Big Island Pond, Otternic Pond, and Robinson Pond.
Chlorophyll-a	↔	No significant regional chlorophyll-*a* trend from 1986 - 2014. Regional median is 5.05 mg/m^3 and is on the high end of mesotrophic conditions or average chlorophyll-*a* levels. Lake specific trend analysis indicates three lakes with significantly increasing (worsening) chlorophyll-*a* levels, five lakes with significantly decreasing (improving) chlorophyll-*a* levels, and ten lakes with stable chlorophyll-*a* trends.
Transparency	↓	Significantly decreasing (worsening) regional transparency trend from 1986 - 2014. The regional median transparency is 3.0 meters and representative of mesotrophic or good conditions. Lake specific trend analysis indicates three lakes with decreasing (worsening) transparency, one with increasing (improving) transparency, and 13 lakes with stable transparency trends.
P	↔	No significant regional epilimnetic phosphorus trend from 1986 – 2014. Regional median epilimnetic phosphorus is 13 ug/L and representative of borderline mesotrophic/eutrophic conditions. Lake specific trend analysis indicates two lakes with significantly decreasing (improving) epilimnetic phosphorus levels, two lakes with significantly increasing (worsening) levels, and 12 lakes with stable epilimnetic phosphorus trends.
DO	N/A	Dissolved oxygen levels fluctuate temporally and spatially within a lake system. Ideal levels are between 6.0 and 8.0 mg/L. The average whole water column dissolved oxygen level was 5.12 mg/L, which is in the critical range for supporting aquatic life.
pH	↓	Significantly decreasing (worsening) regional epilimnetic pH trend from 1986 - 2014. Regional median epilimnetic pH is 7.0 (neutral) and within a desirable pH range. Lake specific trend analysis indicates two lakes with significantly increasing (improving) epilimnetic pH, one with significantly decreasing (worsening) epilimnetic pH, and the remaining 13 lakes with stable epilimnetic pH trends.
Conductivity	↑	Significantly increasing (worsening) regional epilimnetic conductivity trend from 1986 - 2014. The regional median epilimnetic conductivity is 180.0 uMhos/cm which is higher than a NHDESirable however individual lake conductivity fluctuates widely from approximately 17.0 to 965.0 uMhos/cm due to differences in watershed development. Lake specific trend analysis indicates two lakes with significantly decreasing (improving) epilimnetic conductivity, 5 lakes with significantly increasing (worsening) epilimnetic conductivity, and 9 lakes with stable epilimnetic conductivity trends.
NaCl	↔	No significant regional epilimnetic chloride trend from 2002 - 2014. Regional median epilimnetic chloride is 48 mg/L and much less than acute and chronic chloride standards, however is the highest regional median in the state. Lake specific epilimnetic chloride levels range from approximately 10 to 278 mg/L.
Turbidity	↑	Significantly increasing (worsening) regional epilimnetic turbidity trend from 1994 - 2014. Regional median epilimnetic turbidity is 1.04 NTU and indicative of average water quality however median values increased particularly since 2002. Turbidity trend analysis is not conducted on individual lakes. Average epilimnetic turbidity values of individual lakes ranged from 0.56 NTU to 4.24 NTU.

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INTRODUCTION AND HISTORY

New Hampshire is home to approximately 1,200 lakes and ponds, and thousands of river miles. Protecting our lakes and rivers is critical to sustaining New Hampshire's drinking water resources, aquatic and natural environments, recreational and tourism industries.

The New Hampshire Department of Environmental Services (NHDES) recognizes the importance of these waterbodies in maintaining a healthy ecosystem for our current and future generations. Protecting high-quality waters and restoring those that are impaired requires coordination and partnership between federal, state and local governments, non-profits, regional commissions, lake associations and watershed residents.

To help citizens assess the health of New Hampshire's lakes and ponds, NHDES established the Volunteer Lake Assessment Program (VLAP) in 1985. The program is a volunteer-driven cooperative effort between the State and local governments, lake associations and lake residents. VLAP trains citizen volunteer monitors to collect water quality data at lakes and their associated tributaries on a monthly basis during the summer. VLAP compiles, interprets and reports the data back to state, federal and local governments, lake associations and lake residents.

VLAP volunteer monitors are invaluable stewards for New Hampshire's lakes. Volunteer monitoring allows NHDES to establish a strong set of baseline chemical and biological data, determine long-term water quality trends and identify emerging water quality issues. NHDES acts on these findings through its funding and regulatory programs. Volunteers use this information to educate lake and watershed residents, businesses and local governments on best management practices to keep New Hampshire's lakes and ponds clean. They have been, and will continue to be, a key element in protecting the integrity of New Hampshire's lakes.

PROGRAM OVERVIEW

VLAP is a cooperative program between NHDES and lake residents and associations. Approximately 500 volunteers monitor water quality at 170 lakes throughout New Hampshire through VLAP. Interest in the program has grown drastically in the past ten years as citizens have become more aware of the connections between land use activities and water quality. Volunteer monitors continually collect high-quality data on their local waterbodies and educate watershed residents.

Volunteer monitors are trained by NHDES to collect lake water quality data, survey the surrounding watershed, and sample the streams and rivers that are tributaries to the lake. Each of the participating lakes must be visited by a NHDES biologist on a biennial basis. This visit is a valuable event in which the volunteer monitors have an opportunity to discuss water quality and watershed concerns and receive recommendations on potential remediation activities. Also, the event allows NHDES biologists to perform a field sampling techniques audit to evaluate volunteer monitor's ability to collect quality data, and to collect information on additional water quality parameters as necessary. Volunteers then sample on their own for the remaining summer months.

To further encourage volunteer monitoring, NHDES, established partnerships with the Lake Sunapee Protective Association (LSPA), Colby Sawyer College (CSC) in New London, NH, and Plymouth State University (PSU) in Plymouth, NH to operate VLAP satellite laboratories. These satellite laboratories serve as a convenient location for volunteers to borrow sampling equipment and deliver water samples for analysis. These strategic locations serve the Dartmouth Lake Sunapee, North Country and White Mountain regions.

The data gathered by the volunteers are reviewed by NHDES quality assurance officers and satellite laboratory managers and imported into NHDES' Environmental Monitoring Database (EMD). During the winter, NHDES biologists review and interpret the water quality data, perform trend analyses, and compile the results into annual reports. The high-quality data gathered through VLAP also helps NHDES to conduct statewide surface water quality assessments. Assessment results are submitted to the Environmental Protection Agency (EPA) by NHDES every two years as a requirement of the Clean Water Act.

Once the volunteer monitors receive the data and the annual report for their lake, NHDES encourages the volunteers to relay that information to their respective associations, organizations, businesses, and local governments. Volunteers are also kept informed of the latest in lake management and water quality issues through an annual newsletter, technical and educational materials, regional workshops, and information on important legislation. In addition, NHDES biologists give presentations at lake association meetings and participate in youth education events. Educational initiatives, such as those mentioned above, allow volunteers to recognize potential water quality or shoreland violations around the lake and report their findings to NHDES.

MONITORING AND PARAMETER SUMMARY

VLAP encourages the collection of comprehensive data sets on key water quality parameters to determine overall health of the system. Lakes and tributaries are sampled several times each year over a period of years. This establishes baseline water quality data and allows for the discernment of long-term water quality trends. These trends depict lake health and provide invaluable information to NHDES' mission to protect New Hampshire's lakes. The sampling efforts of the volunteer monitors supplement the environmental monitoring efforts of NHDES. Only through the assistance of volunteer monitors can such a high volume of sampling be accomplished throughout the state.

NHDES recognizes the importance of collecting data sets that are representative of varying conditions. VLAP has an EPA-approved Quality Assurance Project Plan (QAPP). The QAPP identifies specific responsibilities of NHDES and volunteers, sampling rationale, training procedures, data management and quality control. NHDES and volunteers adhere to the QAPP regime to ensure high quality and representative data sets are collected.

Volunteers collect samples once per month in June, July and August, with some lakes monitored more or less frequently. Samples are collected at approximately the same location each month at each of the deep spot thermal layer, major tributaries (those flowing year round) and seasonal tributaries during spring run-off. The samples are analyzed for a variety of chemical and biological parameters including: pH, ANC, conductivity, chloride, turbidity, total phosphorus and *E. coli* (optional). Additional in-lake data are also collected at the deep spot including lake transparency (with and without a viewscope), chlorophyll-a, phytoplankton, and dissolved oxygen and temperature profiles. Volunteer monitors are also trained to identify and collect samples of suspicious aquatic plants and cyanobacteria.

Environmental outcomes are measured by making comparisons to established New Hampshire medians, averages, ranges of lake water quality and state water quality standards. If analytical results for a particular sampling station frequently exceed state water quality standards, then additional sampling to identify potential pollution sources is necessary. Volunteers often conduct storm event sampling, tributary bracket sampling, and spring run-off sampling to better assess watershed health and provide additional data to guide lake management decisions.

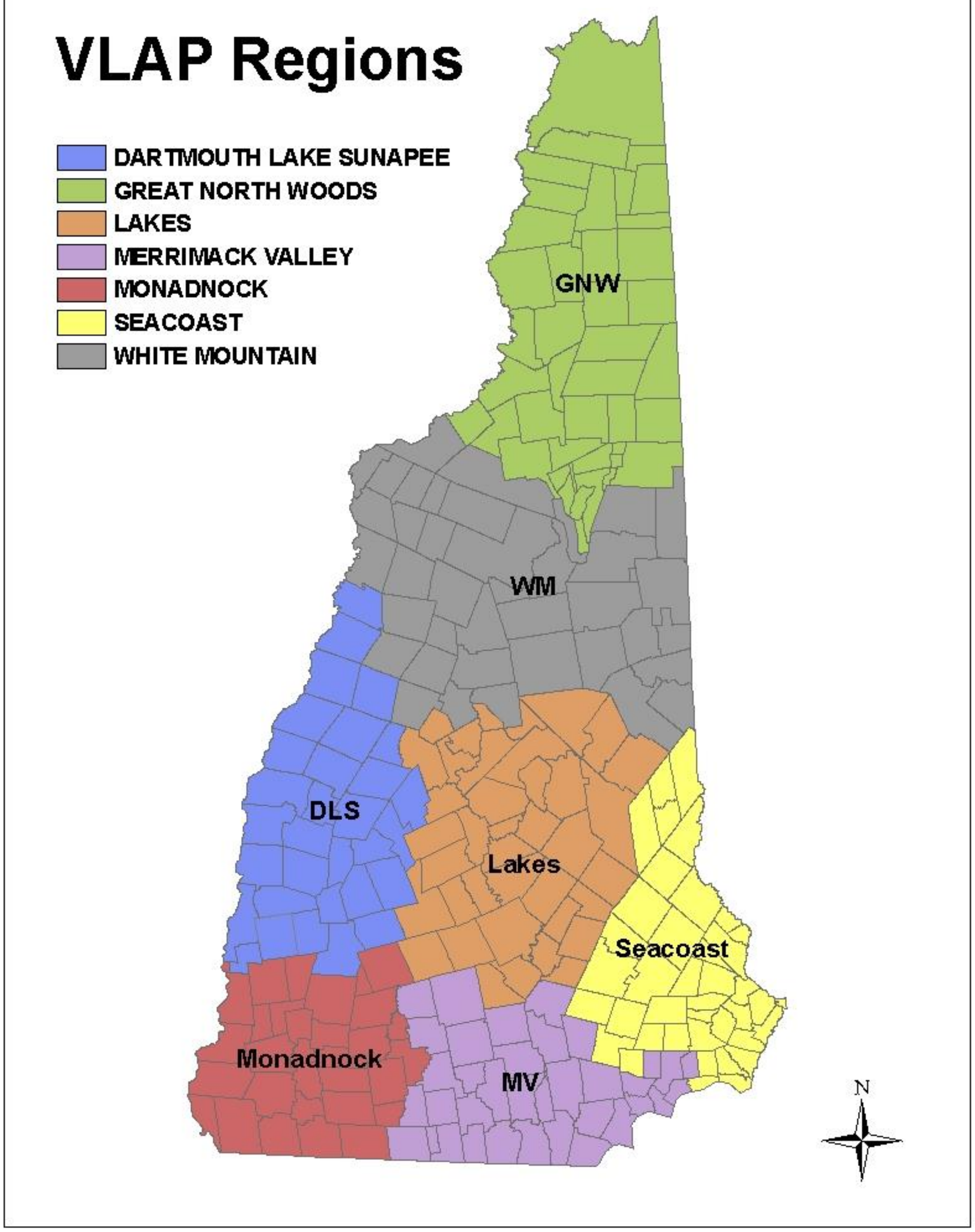
Appendix A includes a summary of each monitoring parameter and Appendix B includes recommended best management practices to remediate pollution sources.

MERRIMACK VALLEY REGIONAL SUMMARY

The Merrimack Valley Region (MV) consists of those towns in New Hampshire's Hillsborough County, western portions of Rockingham County, and southern portions of Merrimack County (Figure 1). This region is marked by the Merrimack River that runs right through the middle. It is home to some of New Hampshire's largest cities, Manchester, Nashua and Salem, and provides a variety of indoor and outdoor recreational activities.

Freshwater resources in the MV region provide valuable drinking water and recreational opportunities and play an important role in the regional economy. Freshwater recreation, including boating, fishing and swimming, in the MV Region generate approximately $44 million dollars in sales, $16 million in household income, and 704 jobs annually (Nordstrom, 2007). A perceived decline in water quality as measured by water clarity, aesthetic beauty or overuse could result in approximately $19.5 million dollars in lost revenue, $7 million in lost household income and 306 lost jobs (Nordstrom, 2007).

Figure 1. VLAP Regions

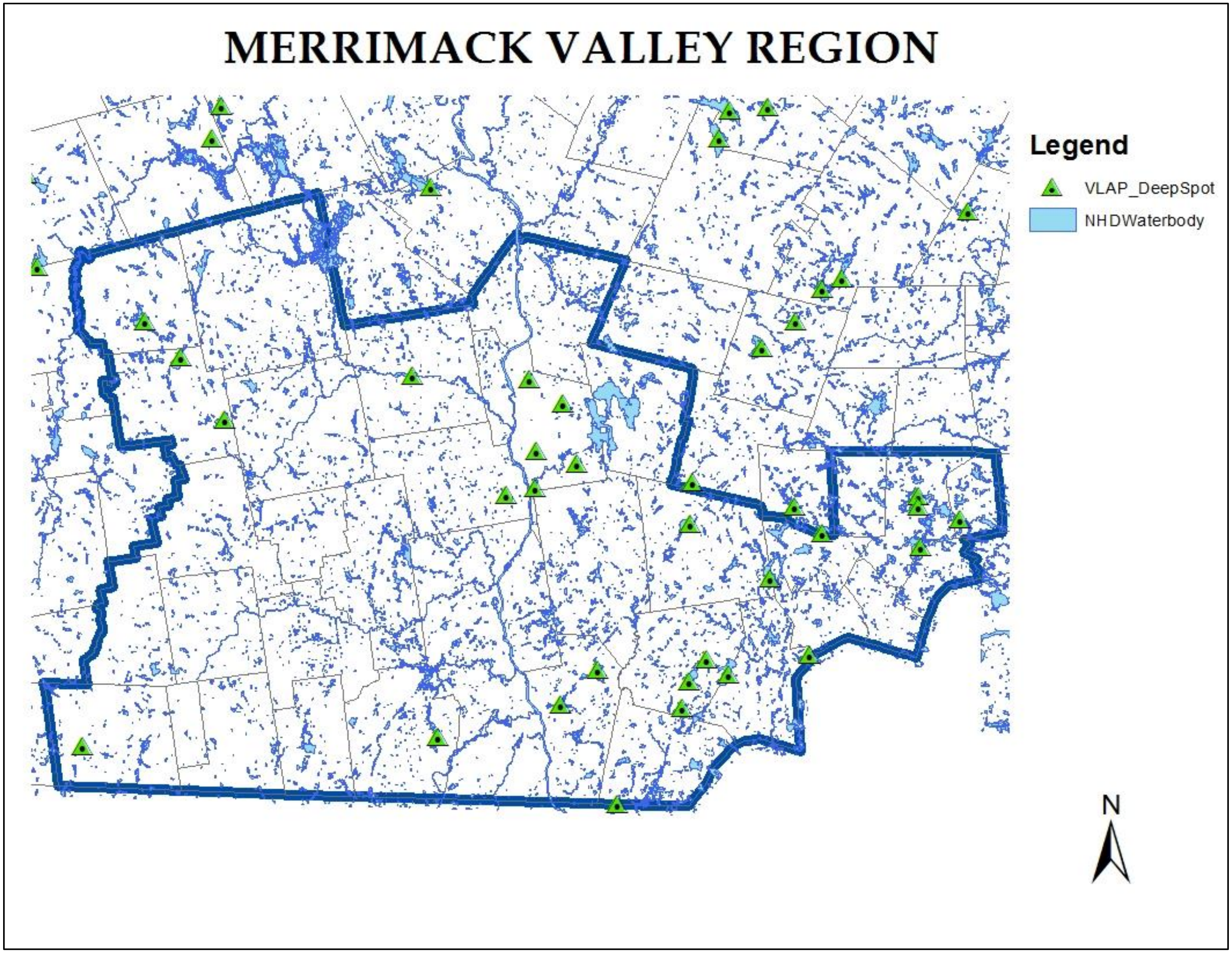


Similarly, a decline in water clarity alone can result in a decrease in New Hampshire lakefront property values. A one meter decrease in water clarity can lead to an average decrease in property values of between 0.9% and 6.0% in New Hampshire (Gibbs, Halstead, Boyle& Huang, 2002). This may negatively impact property tax revenues, especially in a state where there are approximately 64,000 vacation homes concentrated around the Lakes Region (lakes), Seacoast (ocean) and North Country (skiing) (Loder, 2011). According to a 1999 publication of the Society for the Protection of New Hampshire Forests, “The Economic Impact of Open Space in New Hampshire,” vacation homes contribute approximately $286 million to state and local tax revenues (note: open space includes lakes). For a town with a large number of lakefront homes (vacation or residential), a decline in water clarity can cause decreased property values and local tax revenue.

The MV region encompasses the Level 8 Hydrologic Unit Code (HUC) Watersheds of the Merrimack and Nashua Rivers. The HUC boundary defines a specific drainage basin of a major river or series of smaller rivers. There are 18 HUC 8 watersheds in New Hampshire. There are seven VLAP regions (Figure 1). The MV region consists of 24 VLAP lakes (Figure 2) as follows. Individual lake reports can be found in Appendix E.

Lake Name	**Town**
Sebbins Pond	Bedford
Deering Lake	Deering
Beaver Lake	Derry
Big Island Pond	Derry
Powwow Pond	East Kingston
Pleasant Pond	Francestown
Scobie Pond (Haunted Lake)	Francestown
Glen Lake	Goffstown
Angle Pond	Hampstead
Flints Pond	Hollis
Otternic Pond	Hudson
Robinson Pond	Hudson
Great Pond	Kingston
Crystal Lake	Manchester
Dorrs Pond	Manchester
Nutts Pond	Manchester
Pine Island Pond	Manchester
Stevens Pond	Manchester
Pratt Pond	New Ipswich
Long Pond	Pelham
Captains Pond	Salem
Canobie Lake	Windham/Salem
Cobbetts Pond	Windham
Rock Pond	Windham

Figure 2. MV Region Lakes



LAND USE AND POPULATION GROWTH

According to the 2010 update of the Society for the Protection of New Hampshire Forests' publication "New Hampshire's Changing Landscape 2010," New Hampshire's population is expected to increase by 180,000 through 2030 (Figure 3). Almost 70% of that growth will occur in the Southeastern part of the state, particularly in Merrimack, Hillsborough and Rockingham counties.

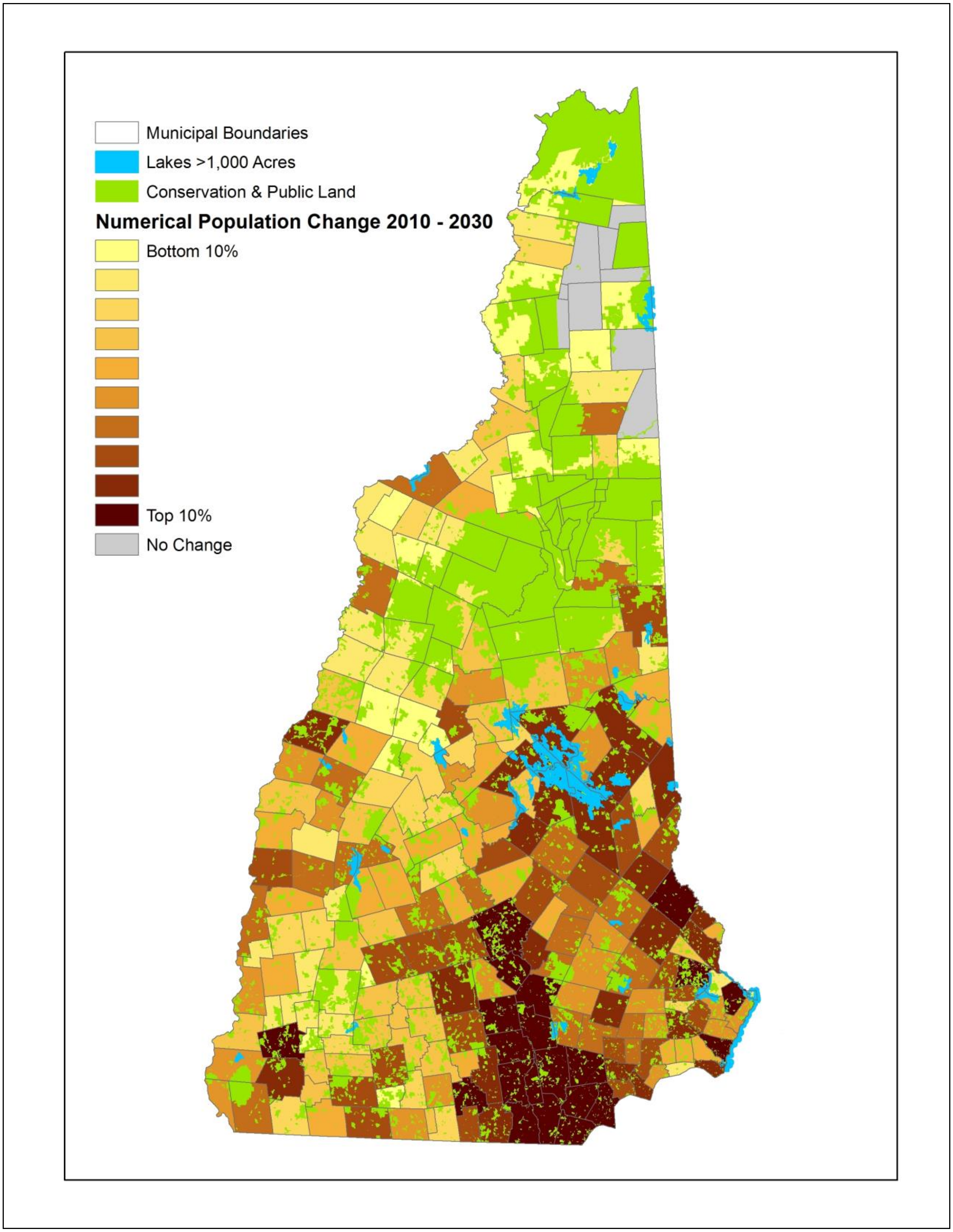
The population is anticipated to grow by approximately 115,000 people in Hillsborough, Rockingham and Merrimack counties by 2030. The majority of growth is estimated to follow main road corridors and urbanizing areas and is anticipated to be greatest in the towns of Goffstown, Manchester, Bedford, Merrimack, Litchfield, Nashua, Hudson, Pelham, Salem, Windham, Derry and Londonderry.

The MV region is home to over 18,000 acres of water (lakes, river, and wetlands). Fifty-nine percent of this water is located in Hillsborough County, 37% is located in Rockingham County, and 4% is located in Merrimack County. Over 7,000 acres of water occurs in the towns predicted to experience the heaviest population growth in these three counties, comprising approximately 40% of the total waterbody acreage in the MV region.

Major land categories in the MV region are agriculture, forest, wetland, residential, and the more urbanized areas of Manchester, Nashua and Salem. Population growth and land use change go hand-in-hand. Growing populations necessitate land clearing to accommodate new homes, housing complexes, roadways and commercial businesses. Developed land corresponds to more impervious surfaces such as roadways, driveways and rooftops. It also corresponds to the loss of tree canopy coverage, unstable sediments, wildlife habitat loss and vegetative buffer loss. Consequences of development can negatively affect our waterbodies through increases in stormwater runoff, water temperatures, erosion, turbidity and nutrients, as well as shifts in aquatic life, aquatic plant, algae and cyanobacteria growth.

Overall, population growth in the MV region could greatly impact a large portion of its waterbodies. Efforts should be made to evaluate current land use activities, infrastructure and regional water quality. This information should facilitate a plan to accommodate projected population growth while conserving and protecting valuable land and water resources.

Figure 3. NH Population Growth per Town 2010-2030



EXOTIC SPECIES

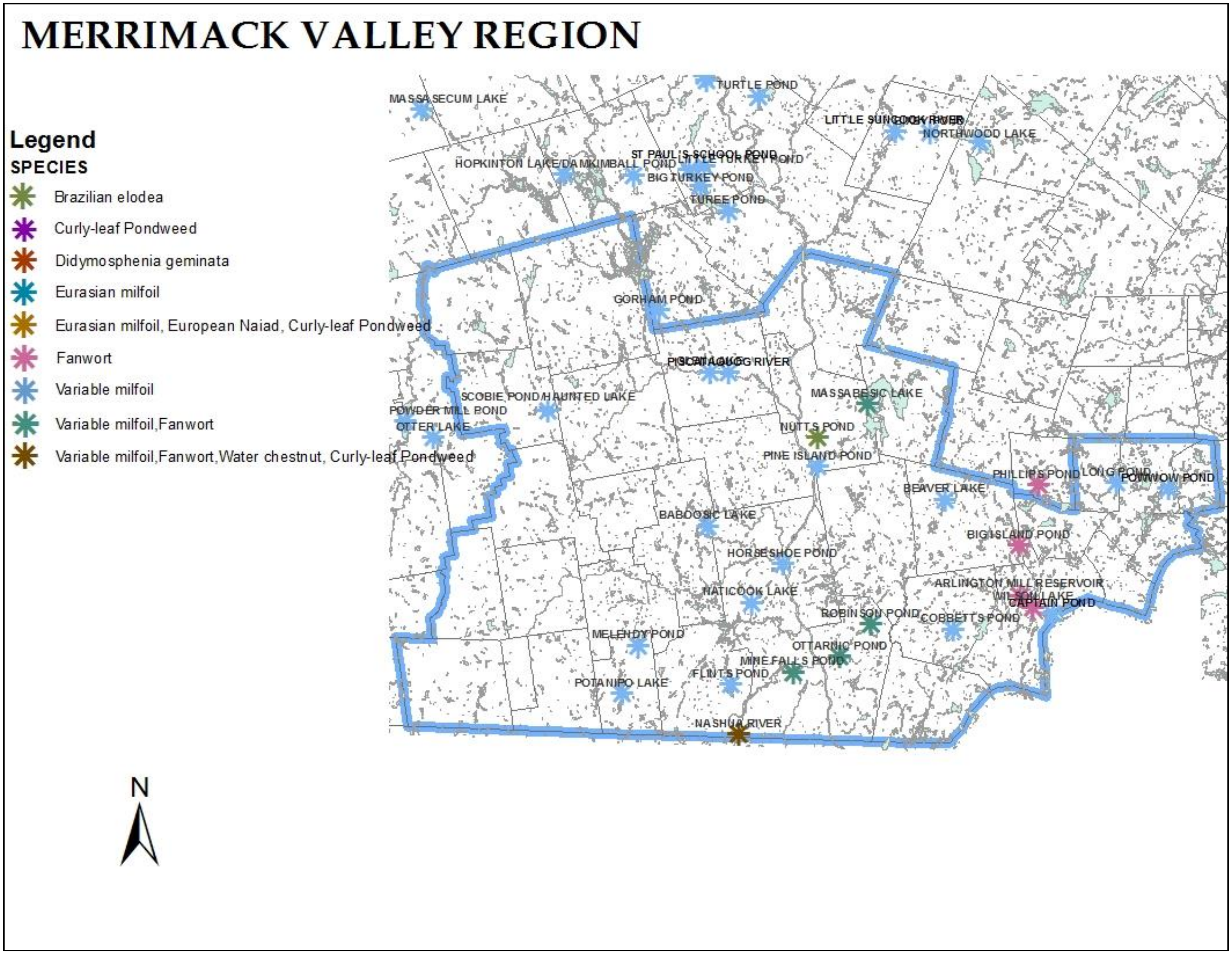
Exotic aquatic nuisance species are those plants and animals not native to New Hampshire's waterbodies, spread quickly through the aquatic environment, negatively affect economic and recreational activities, and can have a detrimental influence on natural habitats, the ecology of the system, and native species. They are a serious threat to the health of New Hampshire's aquatic ecosystems, recreation and tourism industries.

New Hampshire has 106 exotic plant infestations in 85 waterbodies. Those include Variable milfoil, Eurasian milfoil, Brazilian Elodea, Water Chestnut, Curly-leaf Pondweed, Fanwort, European Naiad and *Didymo* (Rock Snot). Variable milfoil inhabits the majority of infested waterbodies, and *Didymo*, an invasive alga, has now infested 54 river miles in the North Country. Currently, 24 waterbodies in the MV region are infested with an exotic species (Figure 4). One new Variable milfoil infestation was discovered in 2014 at Beaver Lake in Derry and another in 2015 at Pine Island Pond in Manchester. Twenty-one waterbodies are infested with Variable milfoil, nine are infested with Fanwort, the Nashua River also has Water chestnut, European naiad, Variable milfoil, Eurasian water milfoil and Curly-leaf Pondweed infestations, and Nutts Pond is infested with Brazilian elodea. Many waterbodies have multiple infestations including Massabesic Lake, Mine Falls Pond, Nashua River, Big Island Pond, Otternic Pond and Robinson Pond. The MV region experiences a range of exotics species that are rare elsewhere in New Hampshire, likely due to higher pH values and alkalinities due to runoff and development making habitat more suitable to some invasive plants that generally would not grow well in New Hampshire.

The unique nature and invasive tendencies of these exotic species heighten the need to prevent new infestations, manage current infestations and engage watershed residents. Public education is integral in preventing further infestations. One program that educates the public and engages watershed residents is the NHDES Weed Watchers Program. The Weed Watchers program has approximately 750 volunteers dedicated to monitoring lakes and ponds for the presence of exotic aquatic plants. Volunteers are trained to survey their lake or pond once a month from May through September. To survey, volunteers slowly boat, or sometimes snorkel, around the perimeter of the waterbody and its islands looking for suspicious aquatic plant species. If a suspicious plant is found, the volunteers send a specimen to NHDES for identification, either in the form of a live specimen, or as a photograph emailed to the Exotic Species Program Coordinator. Upon positive identification, a biologist visits the site to determine the extent of infestation, initiates a rapid response management technique where possible, and formulates a long-term management plan to control the nuisance infestation.

Another program dedicated to public education and engaging watershed residents regarding exotic plant species is the Lake Host™ program, which was developed in 2002 by the non-profit organization New Hampshire Lake Association (NHLA, a.k.a. NH LAKES) and NHDES. The Lake Host™ Program is funded through NHDES and federal grants and provides courtesy boat inspections at boat ramps to prevent invasive species introduction and spread. Since the program was implemented, the number of participating waterbodies, volunteers and number of "saves" (exotic plants discovered) has consistently increased. The program is invaluable in educating boaters, preventing recreational hazards, avoiding property value and aquatic ecosystem decline, addressing aesthetic issues, and saving costly remediation efforts.

Figure 4. MV Region Exotic Aquatic Plant Infestations



GEOMORPHOLOGY AND CLIMATE

Chemical, physical and biological properties of lakes often reflect how they were formed. Lake formation can occur in a variety of ways. In New Hampshire, most lakes were formed during the last ice age as glaciers retreated approximately 12,000 years ago. Lakes are also formed from rivers (oxbow), and are man- and animal-made (e.g., impoundments, dams and beavers). These formations create distinct lake morphology. Included in a lake's morphology are length, width, area, volume and shape. Lake morphology affects the lake's overall ability to adapt to shifts in climate and land use.

Along with the morphological characteristics of lakes, the bedrock and sediment geology is also important in understanding lake properties. Underlying geological properties can affect the pH and ANC of our surface and groundwater. New Hampshire is typically referred to as the "Granite State" because the bedrock geology consists of variations of igneous rock high in granite content that contributes to a lower capacity to buffer acidic inputs such as acid rain. Metamorphic rocks make up the remainder of bedrock geology and consist of slate, schist, quartzite and carbonate rocks which tend to contribute to a more neutral pH and better buffering capacity.

Climate also drives multiple processes in lake systems. Lakes respond to shifting weather conditions such as sunlight, rainfall, air temperature, and wind and wave action in various ways. This variability is reflected in the types and number of biological communities present, and chemical and physical properties of the lake system. It is essential that we understand how these factors influence water quality data collected at individual lake systems. Therefore, volunteers record pertinent weather data, rain and storm event totals on field data sheets while sampling.

To summarize the MV region climate conditions in 2013, the sampling season experienced warmer air temperatures and above average rainfall based on air and precipitation data recorded in Manchester, New Hampshire (Table 1). Air temperatures were warmer than historical averages from May through September resulting in the 2013 average summer air temperature being 1.8° warmer than the historical average. Surface water temperatures were slightly above average for June and July, but were below average in August making the annual summer average surface water temperature approximately equal to the historical average. The 2013 monthly rainfall amounts were above average from May through July and September, and below average in August resulting in the annual average summer precipitation being 0.71 inches greater than the historical average.

In contrast, the 2014 sampling season was slightly cooler and drier. Average air temperatures were slightly above average May through July and September, and average in August resulting in the seasonal average air temperature being 1.1 degrees warmer than the historical average. Surface water temperatures were below average June through August resulting in the annual summer average surface water temperature being 1.0 degrees below the historical average. The 2014 monthly rainfall amounts were below average in May, June and September, above average in July, and average in August making the 2014 summer average precipitation 0.8 inches below the historical average. Annual air and precipitation averages were provided by the National Climatic Data Center and historic averages were provided by the Weather Channel.

Table 1. Current Year and Historical Average Temperature and Precipitation Data for MV Region

	May	June	July	August	September	Summer
2013 Average Air Temperature (°F)	59.4	69.1	75.6	70.9	63.0	67.6
2014 Average Air Temperature (°F)	58.8	68.5	73.9	69.8	63.3	66.9
Average Annual Air Temperature (°F)	**58.0**	**67.0**	**72.0**	**70.0**	**62.0**	**65.8**
2013 Average Surface Water Temperature (°F)	-------	73.8	77.6	74.8	--------	75.4
2014 Average Surface Water Temperature (°F)	-------	71.5	76.9	74.6	--------	74.3
Average Annual Surface Water Temperature (˚F)		**72.7**	**77.0**	**76.1**		**75.3**
2013 Precipitation (in.)	4.17	5.66	4.40	2.93	5.20	4.47
2014 Precipitation (in.)	2.15	1.65	5.82	3.48	1.72	2.96
Average Annual Precipitation (in.)	**3.82**	**4.11**	**3.79**	**3.67**	**3.39**	**3.76**

MONITORING AND ASSESSMENT

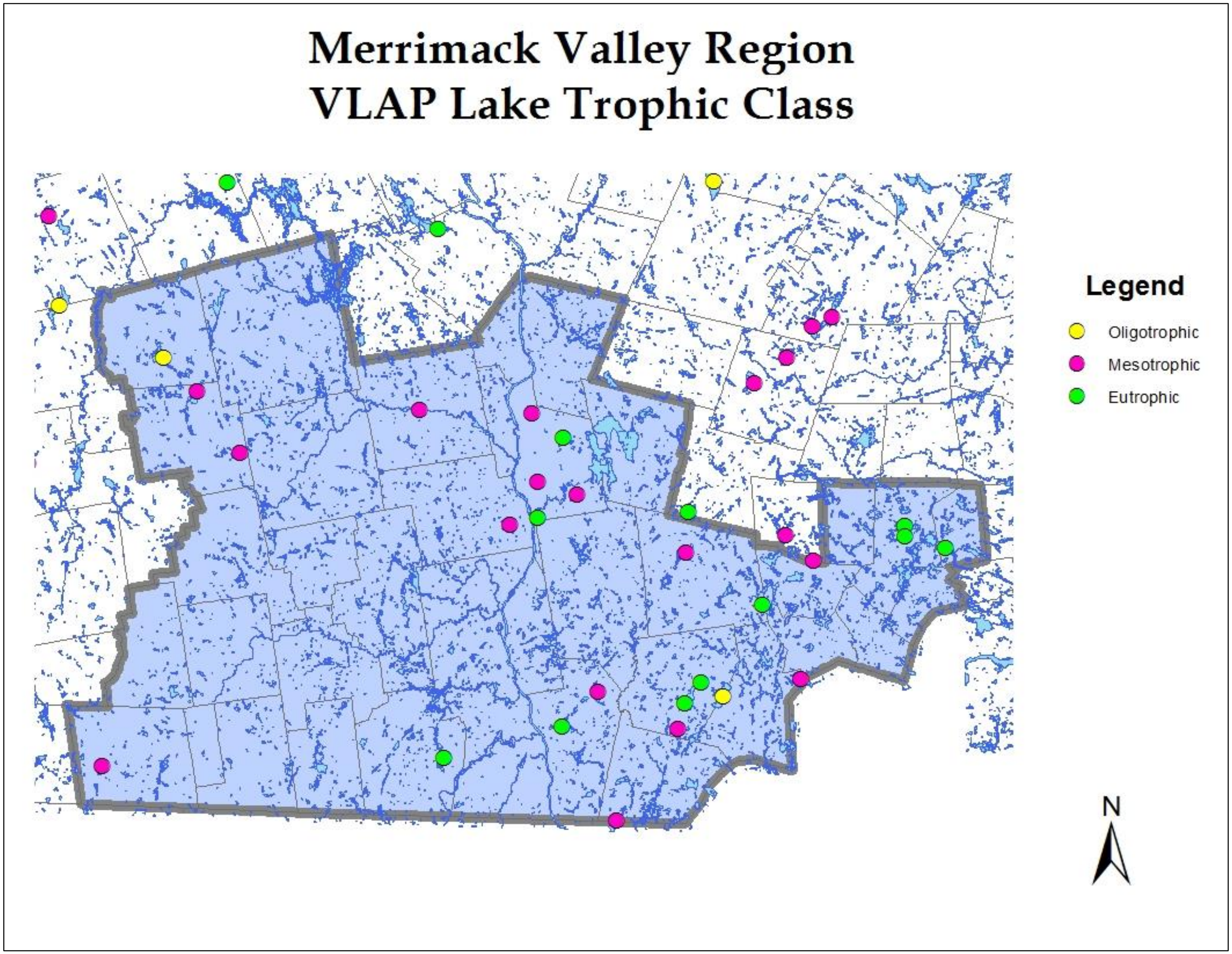
New Hampshire considers a public water to be a great pond or artificial impoundment greater than 10 acres in size, rivers, streams and tidal waters. The MV region consists of 142 lakes, or great ponds, and 24 of those lakes participate in VLAP. Data on the remaining 80% of lakes are sparse, being only occasionally sampled through the NHDES Lake Trophic Survey Program.

The NHDES Lake Trophic Survey Program monitors New Hampshire's lakes on a rotating basis, with the goal of conducting a comprehensive lake survey every 10 to 15 years. The surveys compile chemical, biological and morphological data. The data are used to assign a lake trophic class to each waterbody. The trophic class provides an assessment on lake productivity and can provide information on how population growth and human activities may be accelerating the lake aging process, also known as lake eutrophication.

Three trophic classes are used to assess a lake's overall health, oligotrophic, mesotrophic and eutrophic. Oligotrophic lakes have high dissolved oxygen levels (> 5 mg/L), high transparency (> 12 ft. or 3.65 m), low chlorophyll-a concentrations (< 4 mg/L), low phosphorus concentrations (< 10 ug/L), and sparse aquatic plant growth. Eutrophic lakes have low levels of dissolved oxygen (< 2 mg/L), low transparency (< 6 ft. or 1.8 m), high chlorophyll-a concentrations (> 15 mg/L), high phosphorus concentrations (> 20 ug/L), and abundant aquatic plant growth. Mesotrophic lakes have characteristics that fall in between those of oligotrophic and eutrophic lakes for the parameters listed.

The trophic class breakdown of the MV region lakes is as follows: seven lakes are oligtrophic, 54 mesotrophic, 34 eutrophic, and 41 are un-assessed for trophic classification due to lack of data. Two oligotrophic, 15 mesotrophic, and seven eutrophic lakes participate in VLAP (Figure 5). Approximately 65% of the MV lakes are classified as mesotrophic and eutrophic; and only 5% are considered oligotrophic. As human activities in watersheds accelerate lake aging, it is imperative to keep a close eye on the health of those lakes. Efforts should also be made to gather data on the un-assessed waterbodies. Protecting a lake and preventing lake aging is much more cost-effective than restoring a damaged lake.

Figure 5. MV Region VLAP Lake Trophic Classification



VLAP Water Quality Data Interpretation

The MV region is home to 23 lakes and ponds that participate in VLAP. Volunteer monitors at each lake collect comprehensive data sets at the deepest spot of the lake and from streams entering or exiting the lake. Deep spot sample collection is representative of overall lake quality and is used to establish long-term water quality trends and to provide information into the overall health of the waterbody. Stream sample collection is representative of what flows into the lake from the surrounding watershed. Stream data are used to identify potential watershed pollution problems, such as stormwater inputs, so that remediation actions occur before they negatively impact the overall health of the waterbody.

The following section provides a summary of the VLAP monitoring parameters, long-term water quality trends, and an analysis of the current year and historical data for the VLAP lakes and ponds in the Monadnock region compared with regional and state medians. The deep spot data for the epilimnion, or surface water layer, is compared to the New Hampshire median to provide an understanding of how the quality of a lake deep spot compares to other New Hampshire lake deep spots. Similarly, the epilimnion data are compared to the regional median to provide an understanding of how the quality of your lake deep spot compares with other local lakes. Median values were utilized to represent historical state and regional conditions as the value tends to better represent 'typical' conditions while minimizing the effects of 'extreme' (i.e., outlier) values. Average annual lake and regional values are then compared to the historical medians.

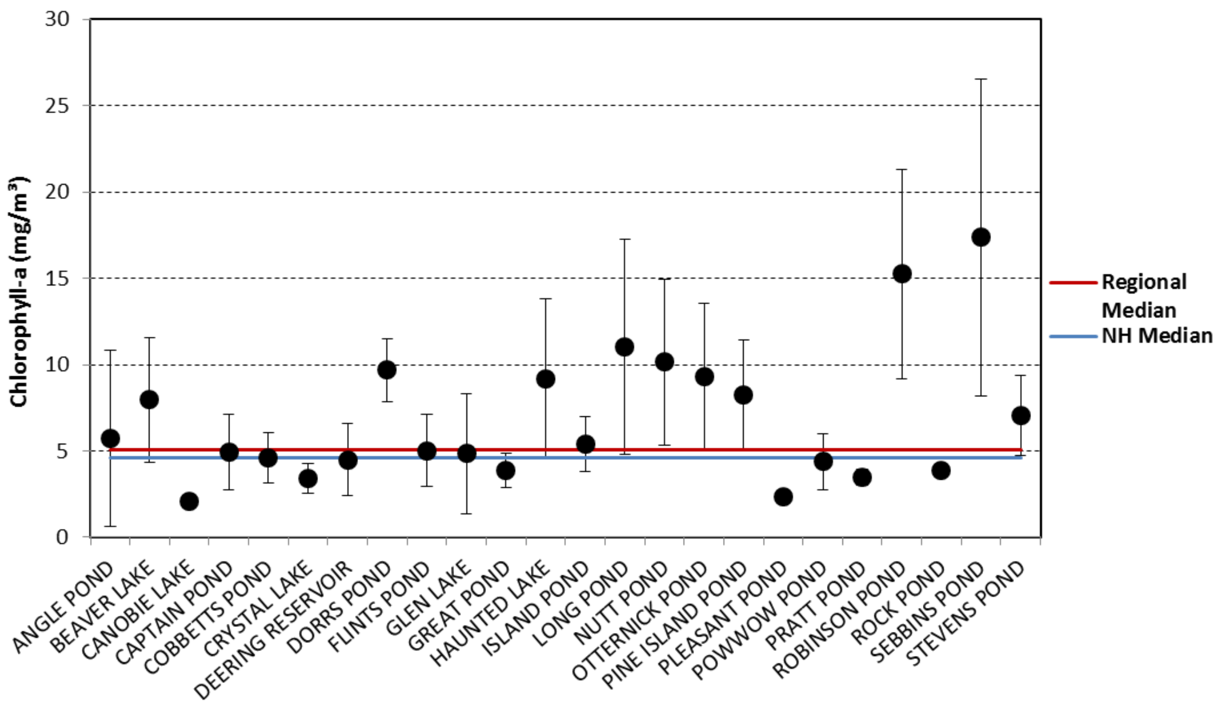
A complete list of monitoring parameters and how to interpret data are included in Appendix A.

Annual and Historical Chlorophyll-a Results

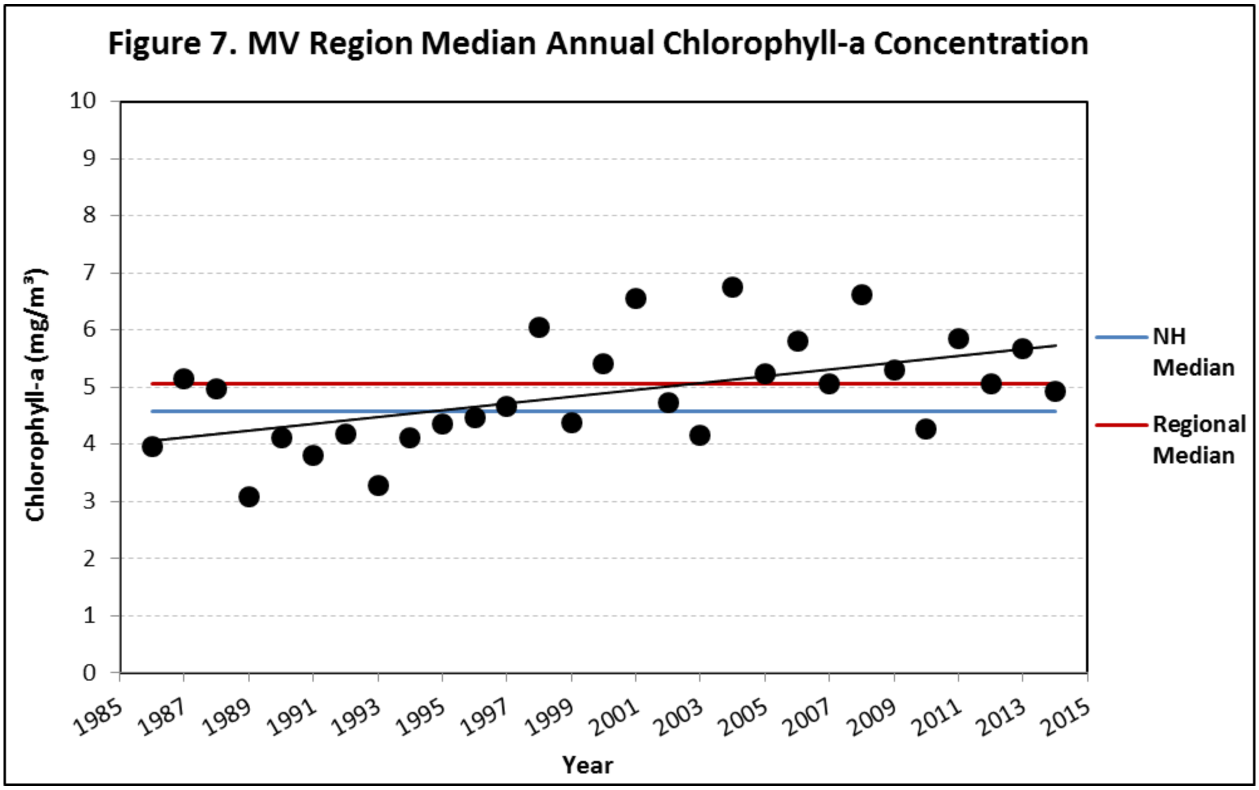
Algae are microscopic plants that are naturally found in the lake ecosystem. Algae, including cyanobacteria, contain chlorophyll-*a*, a pigment used for photosynthesis. The measurement of chlorophyll-*a* in the water gives biologists an estimation of the algal abundance or lake productivity. **The median summer chlorophyll-a concentration for New Hampshire's lakes and ponds is 4.58 mg/m^3. The median chlorophyll-a concentration for the MV region is 5.05 mg/m^3.**

Figure 6 represents the combined 2013 and 2014 average chlorophyll-*a* concentrations for each lake in the MV region compared with state and regional medians. The average chlorophyll-*a* concentration at eight MV lakes is less than state median and typically representative of good water quality. Four lakes have average chlorophyll-*a* concentrations between the regional and state medians representative of average water quality, and twelve lakes have average chlorophyll-*a* concentrations greater than the regional median and representative of poor water quality. Specifically, two of these lakes experienced chlorophyll-*a* concentrations indicative of algal or cyanobacteria blooms. Overall, approximately 60% of the lakes have chlorophyll-*a* concentrations representative of mesotrophic and eutrophic classifications.

Figure 6. Average Chlorophyll-a Concentration for MV Region Lakes



The median annual chlorophyll-*a* concentrations for the MV region are represented in Figure 7. Median chlorophyll-*a* concentrations generally remained between 3.0 and 5.0 mg/m^3 from 1986 through 1997 and then increased to between 4.0 and 7.0 mg/m^3 from 1998-2014. In 2000, the Manchester Urban Ponds joined the program and experienced elevated chlorophyll-*a* concentrations for many years which likely increased the median valule. Due to management efforts in these watersheds, chlorophyll-*a* concentrations have decreased remained lower since 2009 and the median value has remained less than 6.0 mg/m^3 since then as well.



Chlorophyll-*a* Trend Analysis

The regional median chlorophyll-*a* concentration was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A stable trend was detected for the MV region consistent with the majority of state regions (Appendix D: Table D-1).

In addition to the regional trend analysis, MV region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing or stable over time. Chlorophyll-*a* trends were assessed for approximately 18 deep spots at 16 lakes in the region representing 70% of the MV region VLAP lakes. Chlorophyll-*a* concentrations have significantly decreased (improved) at five lake deep spots, significantly increased (worsened) at three lake deep spots, and have remained stable at ten lake deep spots representing 40% of lakes (Table 2; Appendix D: Table D-6). The stable and improving trends are a positive sign as chlorophyll-*a* concentrations are typically related to phosphorus concentrations. Phosphorus is a nutrient that promotes plant and algal growth in New Hampshire lakes. As phosphorus levels increase in lakes, it will normally cause an increase in algal growth.

Table 2. Signficant Chlorophyll-a Trends in MV Region Lakes

Lake Name	Chlorophyll--a	
	Increasing Trend	Decreasing Trend
	p	p
Cobbett’s Pond, STN 1	0.01	
Cobbett’s Pond, STN 2	< 0.01	
Powwow Pond	0.01	
Canobie Lake		< 0.01
Dorrs Pond		0.22
Nutt Pond		0.007
Pleasant Pond		0.02
Rock Pond		0.05

Annual and Historical Transparency Results

Volunteer monitors use the Secchi disk, a 20 cm disk with alternating black and white quadrants, to measure how far a person can see into the water. Transparency, a measure of water clarity, can be affected by algae and sediment in the water, as well as the natural color of the water. Transparency may also be measured using a viewscope, a cylindrical tube, designed to decrease surface water properties that may cause difficulty in viewing the Secchi disk. A comparison of transparency readings collected with and without the use of a viewscope shows that the viewscope typically increases the depth to which the Secchi disk can be seen into the lake, particularly on sunny and windy days. **The median summer transparency for New Hampshire's lakes and ponds is 3.20 meters. The median transparency for the MV region is 3.00 meters.**

Figure 8 represents the combined 2013 and 2014 average transparency for each lake in the MV region compared with state and regional medians. The average transparencies at 14 MV lake deep spots are less than (worse than) the state and regional medians, and generally representative of mesotrophic/eutrophic conditions. Ten lakes have average transparencies greater than (better than) the state and regional medians and are typically representative of mesotrophic/oligotrophic conditions. Lake depth plays an important role when interpreting transparency data. Shallow lakes will typically report lower transparencies than deeper lakes, yet these waterbodies may be quite clear. A better representation would be to look at how transparency changes over time.

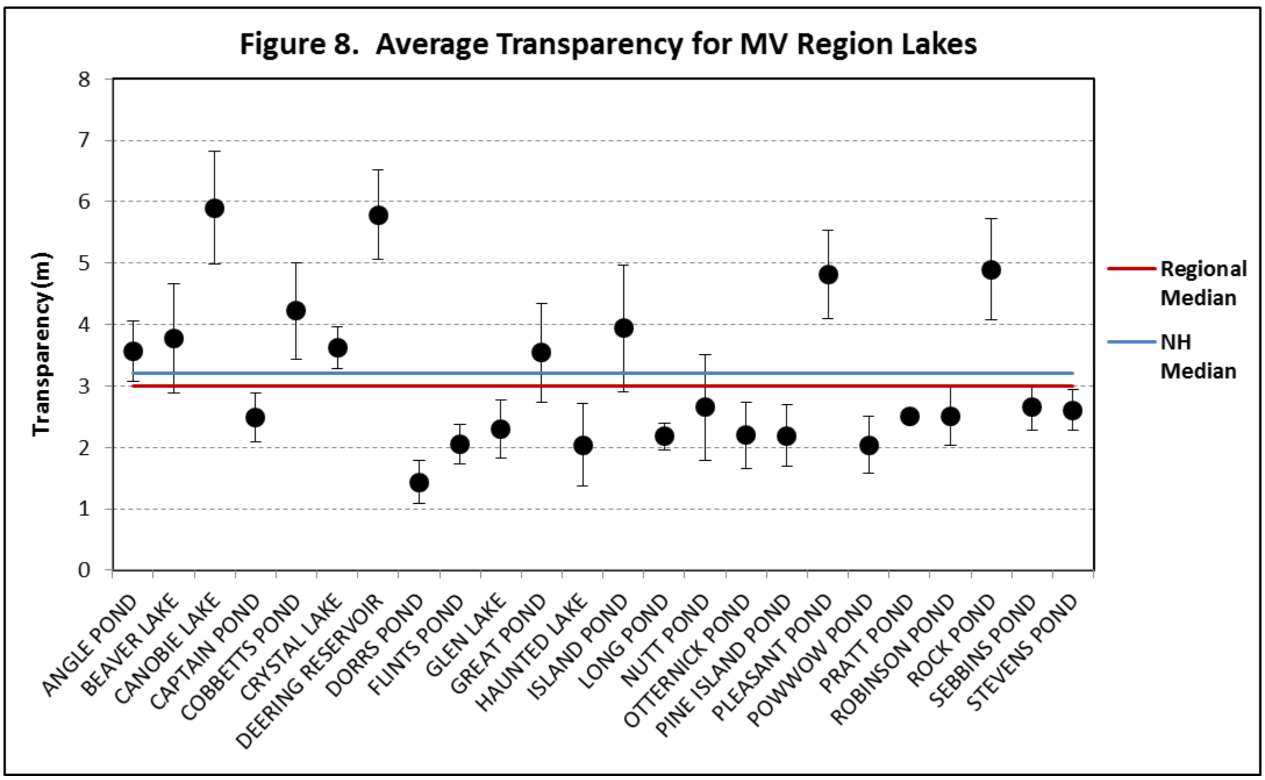
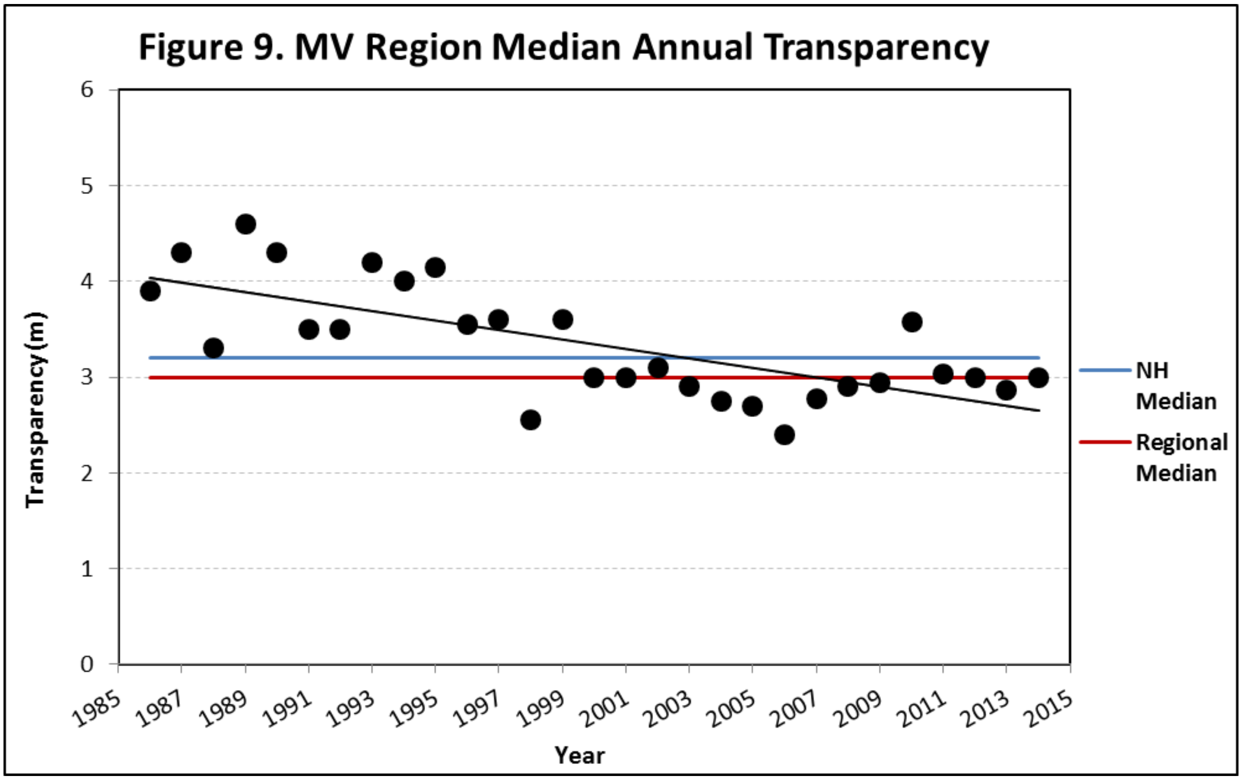


Figure 9 represents the median annual transparency for the MV region. Median transparencies for the region generally remained between 3.5 and 4.5 meters until 1999. Since then, transparencies have decreased to between 2.5 and 3.0 meters which in part can be explained by the urban ponds of Manchester joining the program in 2000, as median chlorophyll-*a* concentrations increased during the same time period (Figure 7). However, it is important to note that since 2000, the transparency has remained relatively stable.



Transparency Trend Analyses

The regional median transparency was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significantly decreasing (worsening) trend was detected for the MV Region which is consistent with the majority of regions (Appendix D: Table D-1).

In addition to the regional trend analysis, MV Region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing or stable over time. Transparency trends were assessed for approximately 17 deep spots at 15 lakes in the region representing 70% of the region's VLAP lakes. Trend analysis revealed three lake deep spots with decreasing (worsening) transparency representing 20% of lakes, one deep spot with significantly increasing (improving) transparency, and 13 lake deep spots with relatively stable transparency trends representing 80% of lakes (Table 3; Appendix D: Table D-6). The majority of regional lakes have stable transparency trends which are a positive sign.

Transparency, or water clarity, is typically affected by the amount of algae, color, and particulate matter within the water column. The stable transparency trends for the region are a positive sign; however transparency at 20% of the lake deep spots is degrading, or getting worse. This cannot be explained by an increase in chlorophyll-*a* or algal growth (Appendix D: Tables D-1, D-6). This suggests that the worsening transparency may be explained by an increase in suspended sediments or water color becoming darker. The increased frequency and intensity of storm events has resulted in an increase in stormwater runoff as well as increased flushing of wetland systems. Stormwater runoff can transport exposed and unstable sediments and other debris to lake systems, thus resulting in decreased transparency. Wetland systems are rich in organic acids that add color to the water, making it appear dark. Lake watersheds with extensive wetland systems may experience decreased transparency due to the influx of dark water during storm events. Transparency impacts due to wetland flushing is a natural occurrence, however erosion due to stormwater runoff can be mitigated to reduce sediments and particulate entering lake systems.

Refer to Appendix B for more information on how to manage stormwater runoff.

Table 3. Significant Transparency Trends in MV Region Lakes

Lake Name	Transparency	
	Increasing Trend	Decreasing Trend
	p	p
Rock Pond	0.005	
Cobbett's Pond, STN 1		0.04
Big Island Pond		0.02
Robinson Pond		0.008

Annual and Historical Total Phosphorus Results

Phosphorus is typically the limiting nutrient for vascular plant and algal growth in New Hampshire's lakes and ponds. Excessive phosphorus in a pond can lead to increased plant and algal growth over time. **The median summer epilimnetic (upper layer) total phosphorus concentration of New Hampshire's lakes and ponds is 12 ug/L. The median epilimnetic total phosphorus concentration of the MV Region is 13 ug/L.**

Figure 10 represents the combined 2013 and 2014 average epilimnetic total phosphorus concentration for MV region lakes compared with state and regional medians. The average epilimnetic phosphorus concentrations at nine lakes is equal to or less than the state median and are representative of oligotrophic/mesotrophic conditions. Fifteen MV lakes have average epilimnetic phosphorus concentrations greater than the regional and state medians and representative of mesotrophic/eutrophic conditions. Total phosphorus concentrations, particularly above 20 ug/L (which five lakes experienced), contribute to excess algal and cyanobacteria growth. Watershed management efforts should address excess phosphorus loading, particularly at these lakes.

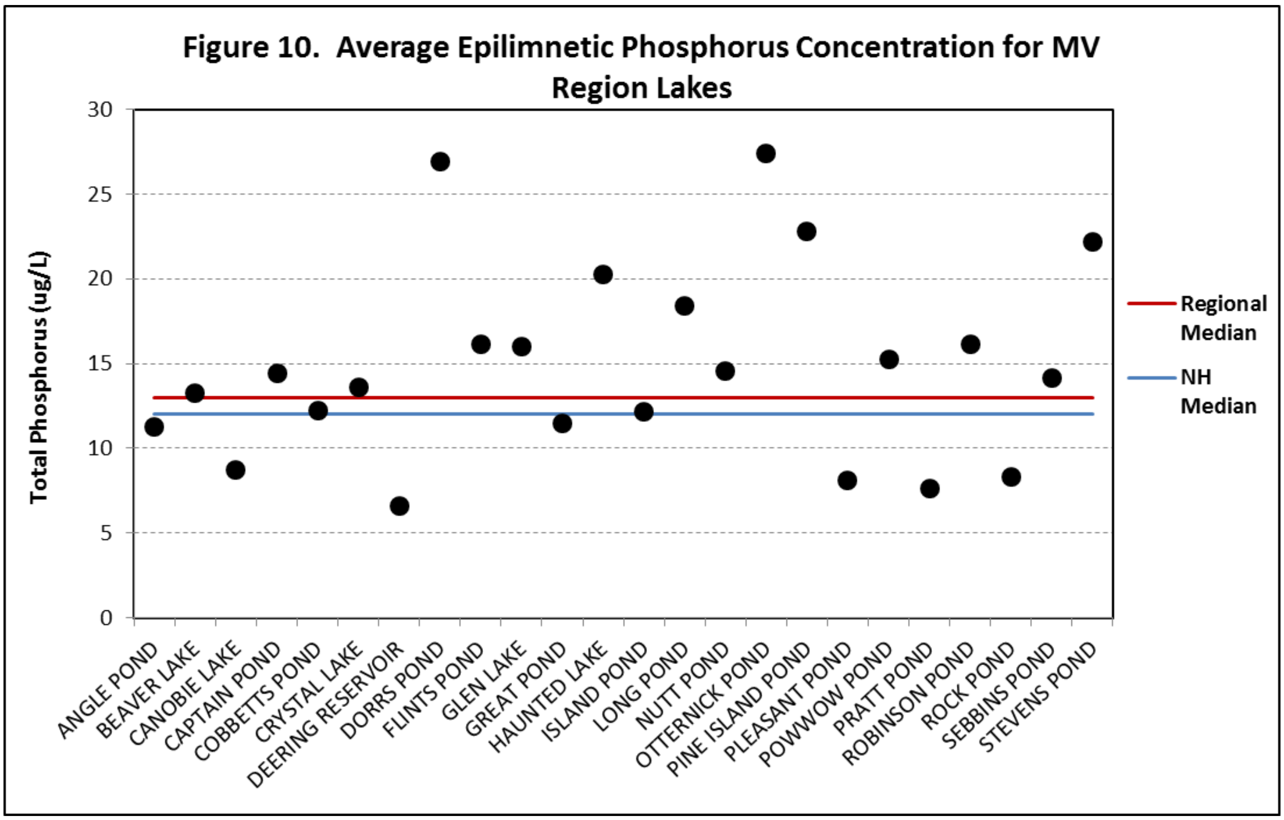
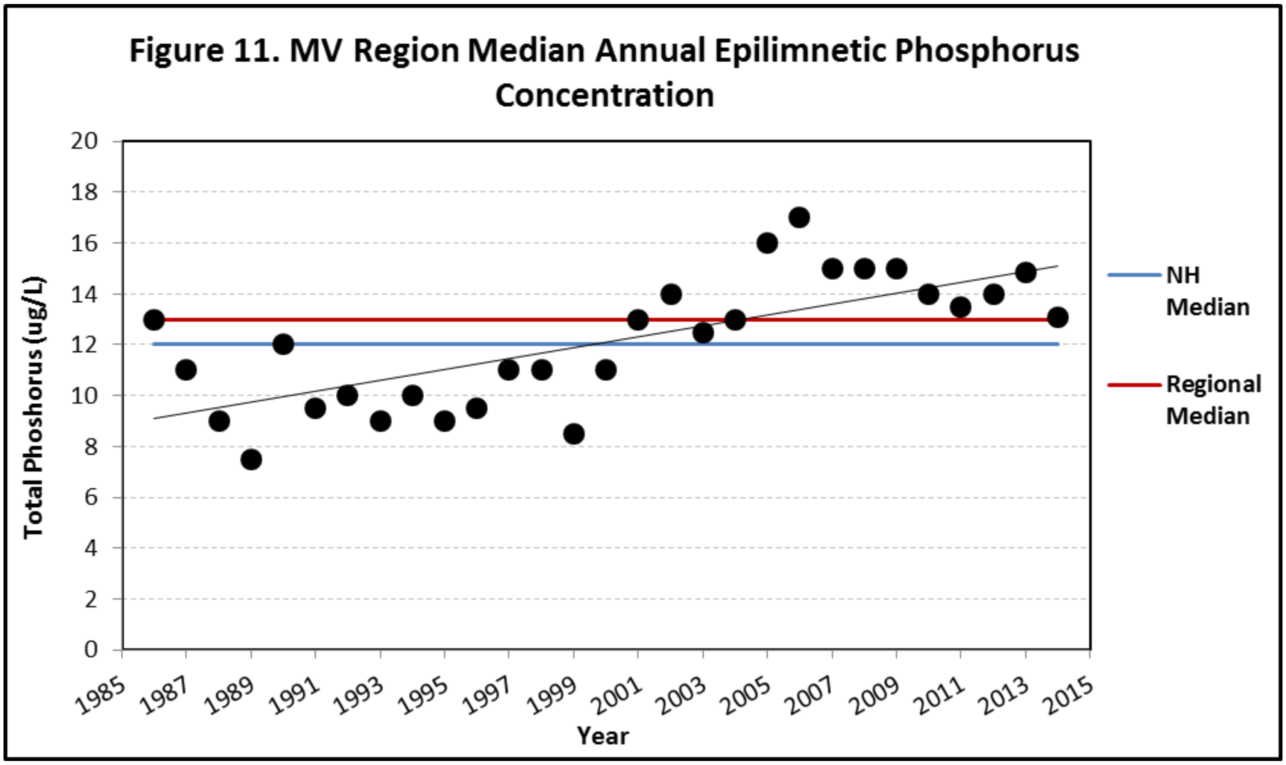


Figure 11 represents the median annual epilimnetic phosphorus concentration for the MV region. The median epilimnetic phosphorus concentration generally remained between 8 and 12 ug/L from 1986 through 1999. Since 2000, when Manchester urban ponds joined the program, the median epilimnetic phosphorus concentrations have increased to between 12 and 18 ug/L contributing to increased algal growth (Figure 7) and lower transparency (Figure 9).



Epilimnetic Phosphorus Trend Analyses

The regional median epilimnetic phosphorus was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A stable trend was detected for the MV Region (Appendix D: Table D-1) which was consistent with the majority of state regions but not the visual trend line (Figure 11).

In addition to the regional trend analysis, MV Region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing or stable over time. Epilimnetic phosphorus trends were assessed for approximately 16 deep spots at 15 lakes in the region representing approximately 60% of the region's VLAP lakes. Trend analysis revealed two lake deep spots with significantly decreasing (improving) phosphorus levels and two lake deep spots with significantly increasing (worsening) phosphorus levels, each representing 13% of regional lakes, while 12 lake deep spots or 74% of region lakes experienced stable trends (Table 4; Appendix D: Table D-6).

The stable epilimnetic phosphorus trends are a positive sign however, increasing epilimnetic phosphorus trends are often a result of phosphorus-enriched stormwater runoff related to increased watershed development. An increase in watershed development often results in an increase in impervious surfaces and unstable sediments. This contributes to an increase in stormwater runoff and sedimentation to rivers and lakes. Efforts should be made to adopt watershed ordinances to limit stormwater runoff and other phosphorus contributions. Watershed residents should be educated on utilizing and installing best management practices to control stormwater runoff from their own properties.

For more information and resources to control phosphorus loading, refer to Appendix B.

Table 4. Significant Epilimnetic Total Phosphorus Trends in MV Region Lakes

Lake Name	Total Phosphorus (Epilimnion)	
	Increasing Trend	Decreasing Trend
	p	p
Crystal Lake	0.03	
Great Pond, North	0.03	
Nutt Pond		0.01
Pleasant Pond		0.05

Dissolved Oxygen Data Analysis

The presence of dissolved oxygen is vital to bottom-dwelling organisms as well as fish and amphibians. If the concentration of dissolved oxygen is low, typically less than 5 mg/L, species intolerant (i.e., sensitive) to this situation, such as trout, will be forced to migrate closer to the surface where there is more dissolved oxygen but the water is generally warmer, and the species may not survive. Temperature and time of day also play a role in the amount of dissolved oxygen in the water column. Water can hold more oxygen at colder temperatures than at warmer temperatures. Therefore, a lake will typically have a higher concentration of dissolved oxygen during the winter, spring, and fall than during the summer. Oxygen concentrations are typically lower overnight than during the day. Plants and algae respire (use oxygen) at night and photosynthesize (produce oxygen) during the day. Dissolved oxygen levels may shift depending on the abundance of aquatic plants and algae in the littoral (near shore) and pelagic (deep water) zones.

Dissolved oxygen and temperature profiles are collected at VLAP lakes on an annual or bi-annual basis. The average dissolved oxygen levels for the MV region is 5.12 mg/L, which is in the critical range for aquatic life support.

For additional information regarding dissolved oxygen, please refer to Appendix A.

Annual and Historical Deep Spot pH Data Analysis

pH is measured on a logarithmic scale of 0 (acidic) to 14 (basic). pH is important to the survival and reproduction of fish and other aquatic life. A pH below 6.0 typically limits the growth and reproduction of fish. A waterbody is considered impaired for aquatic life when the pH falls below 6.5 or above 8.0. **The median epilimnetic pH for New Hampshire's lakes is 6.6, which indicates that the state surface waters are slightly acidic. The median epilimnetic pH for the MV region is 7.00 and neutral.**

Figure 12 represents the combined 2013 and 2014 average epilimnetic pH for individual lakes in the MV region compared with state and regional medians. The state median is significantly lower than the regional median. One lake has an average epilimnetic pH value less than the state median and less than desirable for aquatic life. Eight lakes have average epilimnetic pH values between the state and regional medians and within a desirable range for aquatic life. Fifteen lakes have average epilimnetic pH values greater than the regional median and slightly basic yet within a desirable range for aquatic life. The lowest, most acidic, average pH value was 6.26 measured at Pratt Pond in New Ipswich, and the highest, most basic, pH value was 7.7 measured at Flints Pond in Hollis.

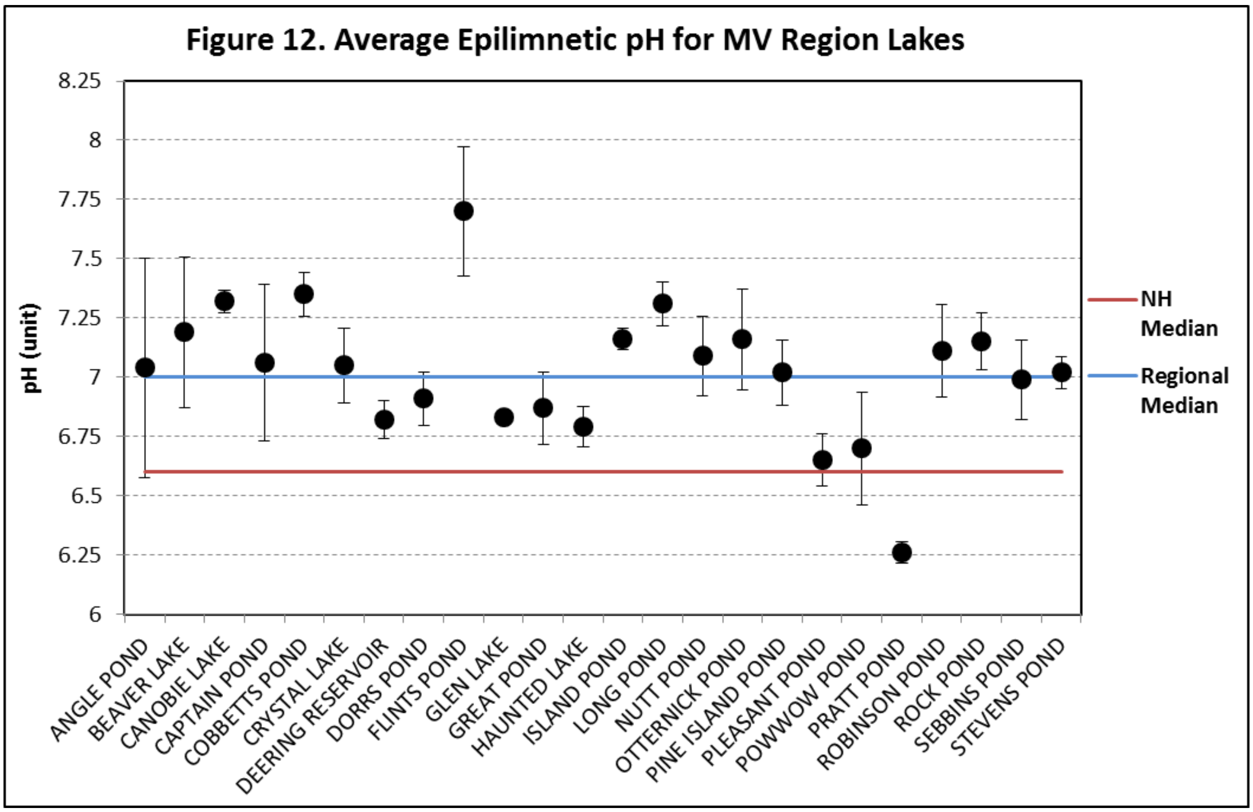
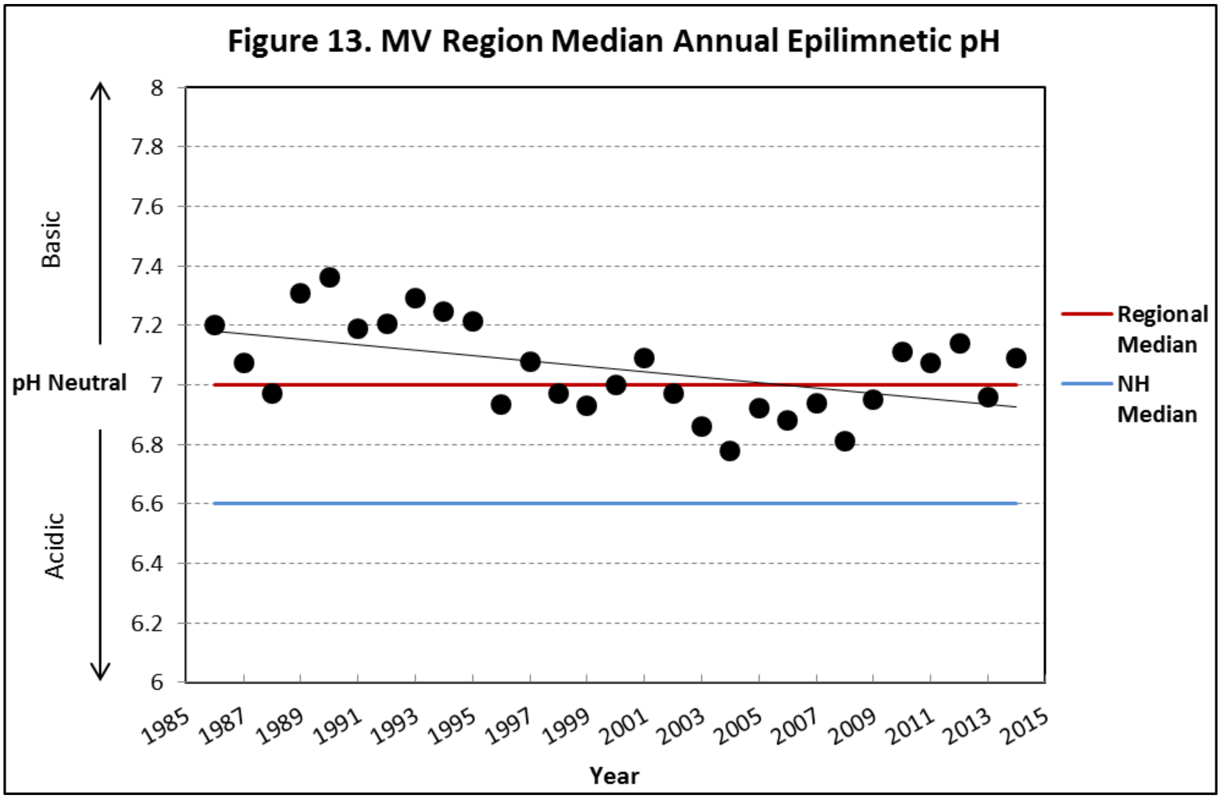


Figure 13 represents the median annual epilimnetic pH value for the MV region compared with the state and regional medians. The median epilimnetic pH generally remained between 7.0 and 7.4 from 1986 to 1997 and then decreased, or became more acidic, and remained between 6.8 and 7.0 from 1998-2009. Since then, the epilimnetic pH has recovered slightly to between 7.0 and 7.2 which is a positive sign.



pH Trend Analysis

The regional median epilimnetic pH was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significantly decreasing (worsening) epilimnetic pH trend was detected for the region (Figure 13; Appendix D: Table D-1). The MV and DLS regions are the only regions that have experienced a significant decrease in epilimnetic pH; however MV region epilimnetic pH appears to be recovering slightly since 2009.

In addition to the regional trend analysis, MV region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing, or stable over time. Epilimnetic pH trends were assessed for approximately 16 deep spots at 15 lakes in the region representing approximately 60% of the region's lakes. Trend analysis revealed two lake deep spots with significantly increasing (improving) epilimnetic pH representing 13% of regional lakes, one deep spot with significantly decreasing (worsening) epilimnetic pH, and 13 lake deep spots with stable epilimnetic pH levels representing 80% of regional lakes (Table 5; Appendix D: Table D-6).

Variations in pH values between lakes and between different geographical regions may depend on the composition and weathering of underlying bedrock and the lake water chemistry. Another contributing factor to pH is acid deposition received as a result of emissions from power plants and vehicles. This increases levels of atmospheric carbon, nitrogen and sulfur which fall back to the earth in the form of acidic precipitation.

A recent report published by NHDES, "Acid Rain Status and Trends New Hampshire Lakes, Ponds and Rainfall" analyzed trends in historical pH, ANC, conductivity, sulfate and nitrate concentrations from three state-wide monitoring programs to determine if the state's lakes and ponds are recovering from the effects of acid rain. The Acid Outlet, Remote Pond and Rooftop Rain programs have been collecting data since the early 1970s and 1980s. Analysis of sulfate, nitrate and pH concentrations of precipitation indicate that pH levels have significantly increased (become less acidic), and sulfate and nitrate concentrations have significantly decreased (improved) since 1972. Analysis of sulfate, nitrate, pH, and ANC concentrations of lake water indicate that the majority of lakes sampled have experienced a stable trend or increase (improvement) in pH and ANC as well as a 90% reduction in sulfate and nitrate concentration. This supports significant improvements in local and national air quality as regulations have improved acid rain; however, our surface waters reflect a slower rate of recovery.

Table 5. Significant Epilimnetic pH Trends in MV Region Lakes

Lake Name	pH (Epilimnion)	
	Increasing Trend	Decreasing Trend
	p	p
Canobie Lake	0.04	
Powwow Pond	0.02	
Rock Pond		0.02

Annual and Historical ANC Data Analysis

ANC measures the buffering capacity of a water body, or its ability to resist changes in pH by neutralizing acidic inputs. These "buffers" are typically bases such as bicarbonate and carbonate. Geology can play an important part in a water body's buffering capacity. Lakes located in areas with predominantly limestone (calcium carbonate), sedimentary rocks and carbonate-rich soils often have a higher ANC, while lakes located in areas with predominantly granite and carbon-poor soils often have a lower ANC. The higher the ANC, the more readily a waterbody can resist change in pH. **The median ANC value for New Hampshire's lakes and ponds is 4.8 mg/L, and the median ANC value for the MV region is 14.2 mg/L, which indicates that many lakes and ponds in the region have a *low vulnerability* to acidic inputs.**

Figure 14 represents the combined 2013 and 2014 average epilimnetic ANC for individual lakes in the MV Region. Two lakes have average epilimnetic ANC values less than the state median and considered *highly vulnerable* to acidic inputs. Six lakes have average epilimnetic ANC values between the state and regional medians and considered *moderately vulnerable* to acidic inputs. Sixteen lakes have average epilimnetic ANC values greater than the regional median and have *moderate to low vulnerability* to acidic inputs. The lowest ANC measured was 1.7 mg/L at Pratt Pond in New Ipswich and the highest ANC measured was 36.7 mg/L at Otternic Pond in Hudson.

Figure 14. Average ANC for MV Region Lakes

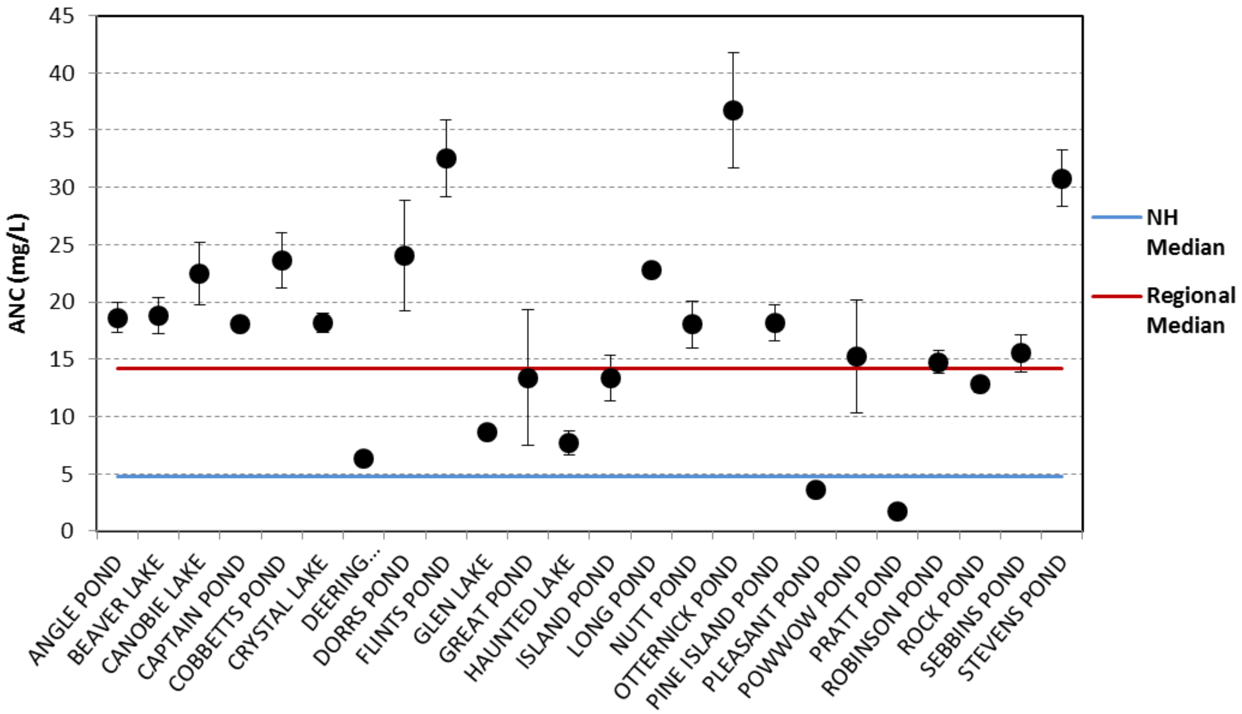
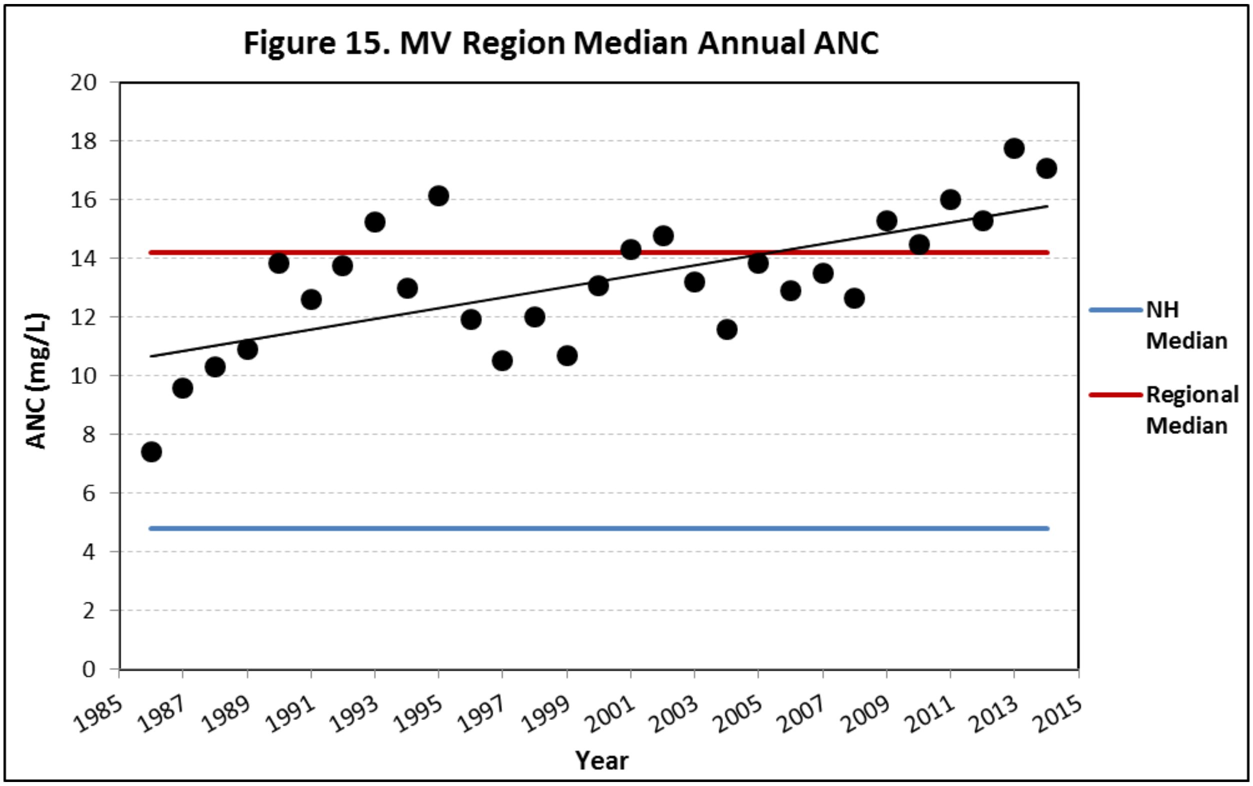


Figure 15 represents the median annual ANC for the MV region. The median ANC generally remained between 10.0 and 14.0 mg/L between 1986 and 2008. Since then, the median ANC has increased to between 14.0 and 18.0 mg/L which is consistent with the improved epilimnetic pH during this period (Figure 13). The 2013 and 2014 median ANC values were the highest (best) measured since monitoring began.



Acid Neutralizing Capacity Trend Analysis

The regional median ANC was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significantly increasing (improving) trend was detected for the MV region (Appendix D: Table D-1; Figure 15). This further supports the NHDES "Acid Rain Status and Trends New Hampshire Lakes, Ponds and Rainfall" report.

Annual and Historical Deep Spot Conductivity Data Analysis

Conductivity is the numerical expression of the ability of water to carry an electric current, which is determined by the number of negatively charged ions from metals, salts, and minerals in the water column. The soft waters of New Hampshire have traditionally low conductivity values, generally less than 50 uMhos/cm. However, specific categories of good and bad levels cannot be constructed for conductivity because variations in watershed geology can result in natural fluctuations. **The median conductivity value for New Hampshire's lakes and ponds is 40.0 uMhos/cm. The median epilimnetic conductivity value for the MV region is 180.0 uMhos/cm.**

Figure 16 represents the combined 2013 and 2014 average epilimnetic conductivity for individual lakes in the MV region. The regional median is significantly higher than the state median and indicative of the more urbanized landscape. Two lakes have average epilimnetic conductivity values less than the state median and indicative of more rural landscapes. Eight lakes have average epilimnetic conductivity values between the state and regional medians, and fourteen lakes have average epilimnetic conductivity values greater than the regional median. Conductivity values fluctuate widely among the region's lakes. The lowest average conductivity value of 17.03 uMhos/cm was measured at Pratt Pond in New Ipswich whereas the highest average value of 964.67 uMhos/cm was measured at Stevens Pond in Manchester. A wide range of watershed types and degrees of development exists in the region. Pratt Pond's watershed has minor developmental pressure when compared to Stevens Pond in Manchester which abuts I-93 and receives stormwater runoff from the highway.

Figure 16. Average Epilimnetic Conductivity for MV Region Lakes

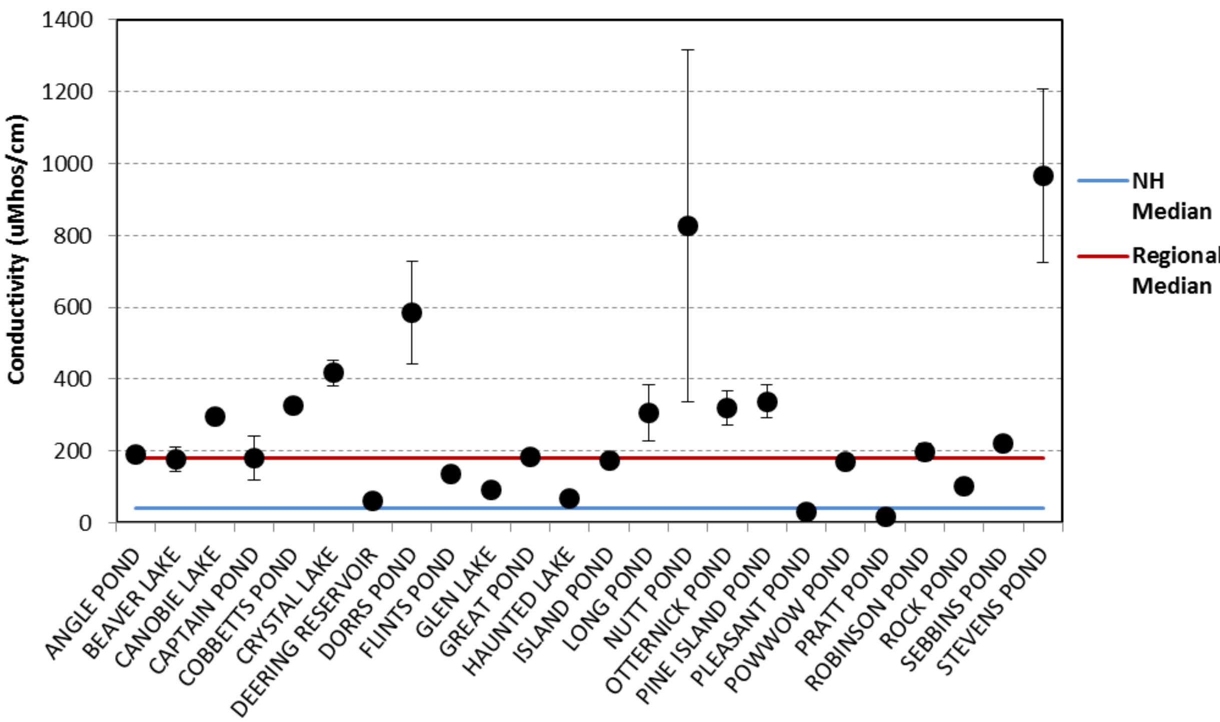
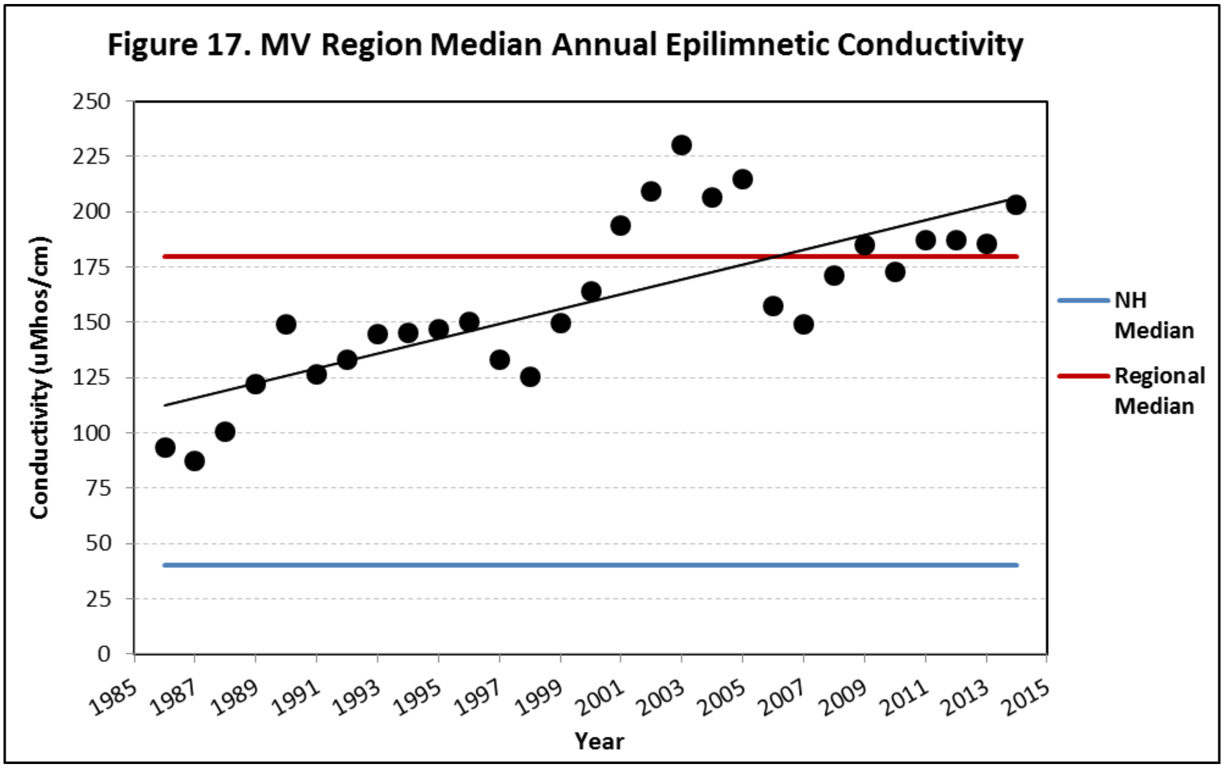


Figure 17 represents the median annual epilimnetic conductivity for the MV region compared with regional and state medians. Prior to the Manchester Urban Ponds joining VLAP in 2000, the median regional conductivity ranged from 100.0 and 150.0 uMhos/cm, but jumped greatly with the addition of the urban ponds to between 150.0 and 230.0 uMhos/cm. These ponds receive a large amount of stormwater runoff from impervious surfaces which has resulted in extremely elevated conductivities. The implementations of stormwater best management practices around the urban ponds has resulted in lower conductivity levels and is reflected in the lower median values measured since 2006.



Historical Conductivity Trend Analysis

The regional median epilimnetic conductivity was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significantly increasing (worsening) epilimnetic conductivity trend was detected for the MV region which is consistent the majority of state regions (Figure 17; Appendix D: Table D-1).

In addition to the regional trend analysis, MV region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing, or stable over time. Epilimnetic conductivity trends were assessed for approximately 16 deep spots at 15 lakes in the region representing approximately 60% of the region's VLAP lakes. Trend analysis revealed two lake deep spots with significantly decreasing (improving) epilimnetic conductivity representing 13% of regional lakes, five deep spots with significantly increasing (worsening) epilimnetic conductivity, representing 27% of regional lakes and nine lakes with relatively stable epilimnetic conductivity, representing 60% of regional lakes (Table 6; Appendix D: Table D-6).

Generally, conductivity values in New Hampshire lakes exceeding **100 uMhos/cm** indicate cultural, meaning human, disturbances. An elevated conductivity trend typically indicates point sources and/or non-point sources of pollution are occurring within the watershed. These sources include failed or marginally functioning septic systems, agricultural runoff, road runoff and groundwater inputs. New development in the watershed can alter runoff patterns and expose new soil and bedrock areas, which could also contribute to increasing conductivity. In addition, natural sources, such as mineral deposits in bedrock, can influence conductivity.

Table 6. Significant Epilimnetic Conductivity Trends in MV Region Lakes

Lake Name	Conductivity (Epilimnion)	
	Increasing Trend	Decreasing Trend
	p	p
Crystal Lake	0.02	
Great Pond, North	0.005	
Great Pond, South	<0.003	
Big Island Pond	0.01	
Rock Pond	0.05	
Captain's Pond		0.02
Powwow Pond		0.01

Annual and Historical Deep Spot Chloride Data Analysis

High conductivity values are often due to elevated chloride levels, which are generally associated with road salt and/or septic inputs. The chloride ion (Cl^-) is found naturally in some surface and ground waters and in high concentrations in seawater. The chloride content in New Hampshire lakes is naturally low in surface waters located in remote areas away from habitation. Research has shown that elevated chloride levels can be toxic to freshwater aquatic life. In order to protect freshwater aquatic life in New Hampshire, the state has adopted acute and chronic chloride criteria of 860 and 230 mg/L respectively. **The median chloride value for New Hampshire's lakes is 4 mg/L. The median epilimnetic chloride value for the MV region is 48 mg/L.**

Figure 18 represents the combined 2013 and 2014 average epilimnetic chloride levels of individual lakes in the MV region. The regional median is much higher than the state median however is not greater than the state acute and chronic standards for chloride in surface waters. Nine lakes have average epilimnetic chloride levels between the state and regional medians and eleven lakes have average epilimnetic chloride levels equal to or greater than the regional median. Both Nutts Pond and Stevens Pond, two Manchester Urban Ponds, have chloride levels greater than the state chronic chloride standard of 230 mg/L. The chloride measurement is relatively new for VLAP and is an optional analyte for participating lakes. Lakes that serve as water supplies or where conductivity levels may be influenced by chloride are analyzed annually.

Figure 18. Average Epilimnetic Chloride for MV Region Lakes

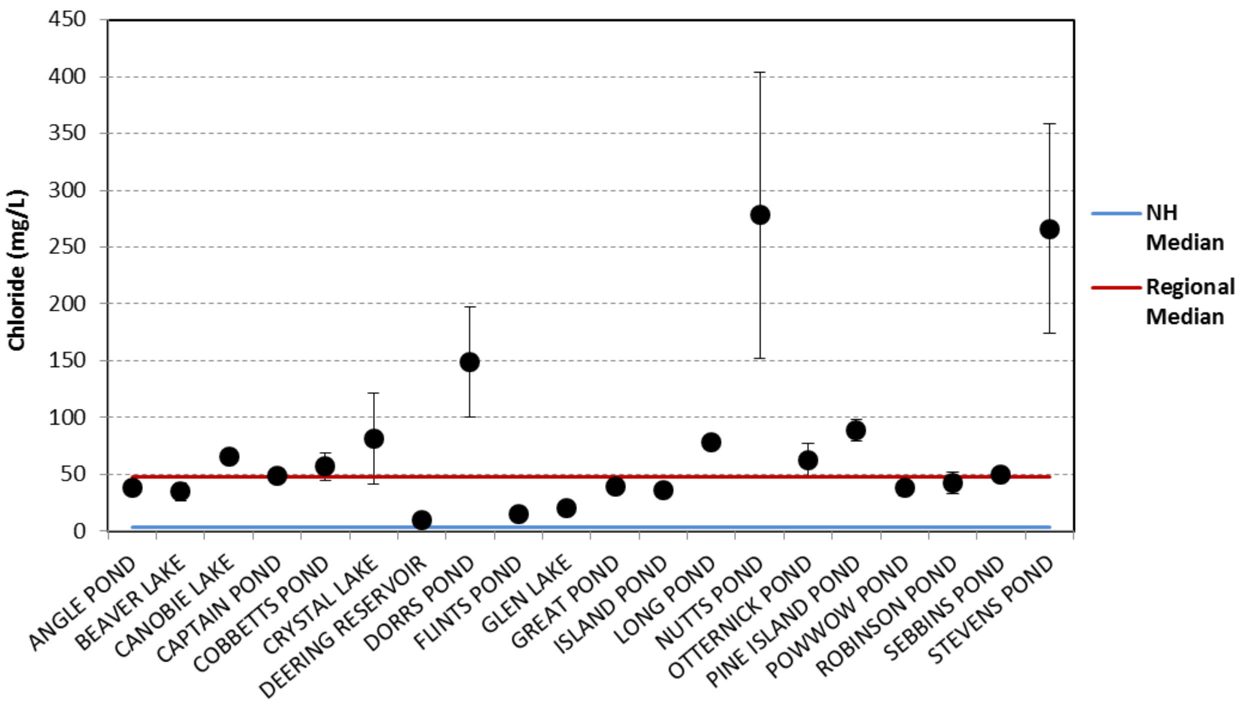
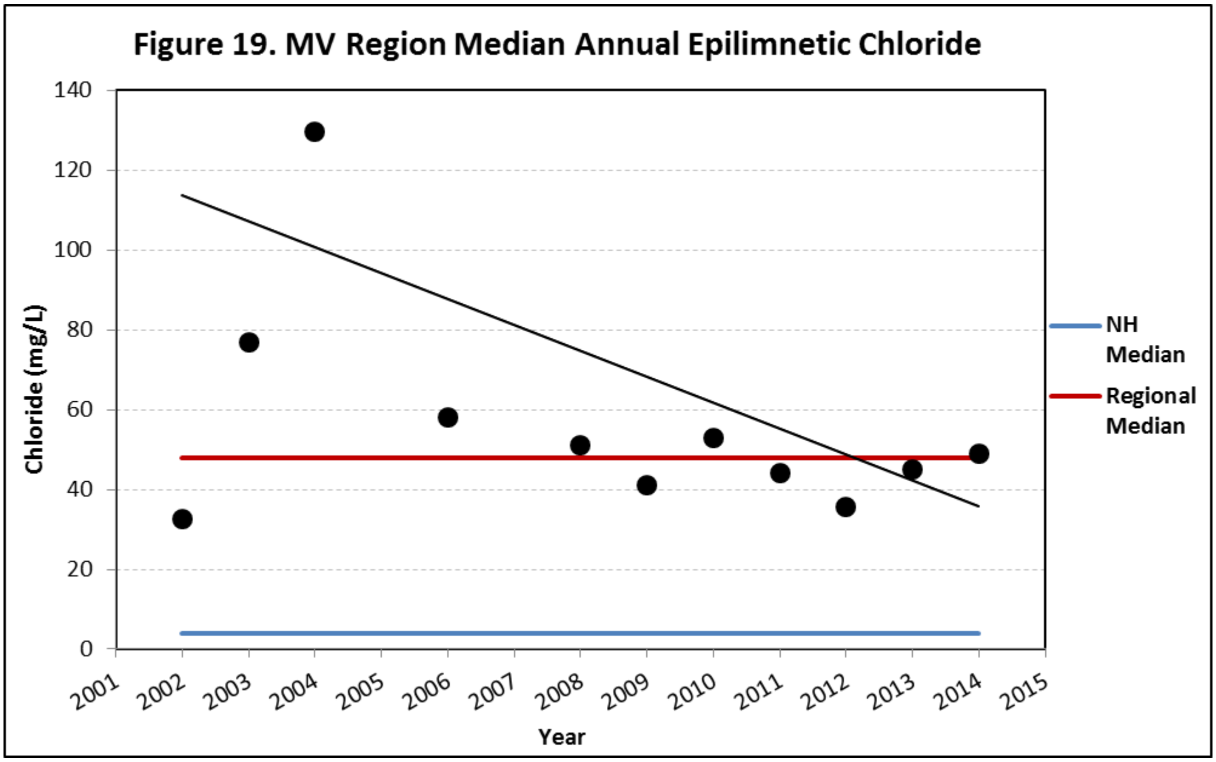


Figure 19 represents the median annual epilimnetic chloride levels for the MV region. Prior to 2008, chloride levels were analyzed mainly on the Manchester Urban Ponds and from 2008 through 2014 the majority of regional lakes were analyzed for chloride. The regional epilimnetic chloride level has remained stable since 2008. Median epilimnetic chloride levels generally range between 40 and 60 mg/L and are less than the state acute and chronic chloride standards; however, they are greater than what we would typically measure in undisturbed New Hampshire surface waters.



Historical Chloride Trend Analysis

The regional median epilimnetic chloride was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. No significant trend was detected for the MV region (Appendix D: Table D-1, Figure 19). This trend is consistent with all state regions.

Watershed management efforts to control un-natural sources of conductivity and chloride in waterbodies should employ a combination of best management practices in regards to winter salting practices. State and local governments and private homeowners should evaluate the use of road salt and alternatives to reduce the amount of material applied while maintaining public safety.

For additional information on the relationship between conductivity and chloride, please refer to Appendix A. For additional information on best management practices, please refer to Appendix B.

Annual and Historical Deep Spot Turbidity Data Analysis

Turbidity in the water is caused by suspended matter (such as clay, silt and algae) that cause light to be scattered and absorbed, not transmitted in straight lines through water. Water clarity is strongly influenced by turbidity. **The Class B surface water quality standard for turbidity is no greater than 10 NTUs over the lake background level. The median epilimnetic turbidity for the MV region is 1.04 NTU.**

Figure 20 represents the combined 2013 and 2014 average epilimnetic turbidity for individual lakes in the MV region. Twelve lakes have average epilimnetic turbidities less than the regional median and 1.2 NTU and considered to be within a low to average range. Twelve lakes have average epilimnetic turbidities greater than the regional median and 1.2 NTUs and higher than desirable.

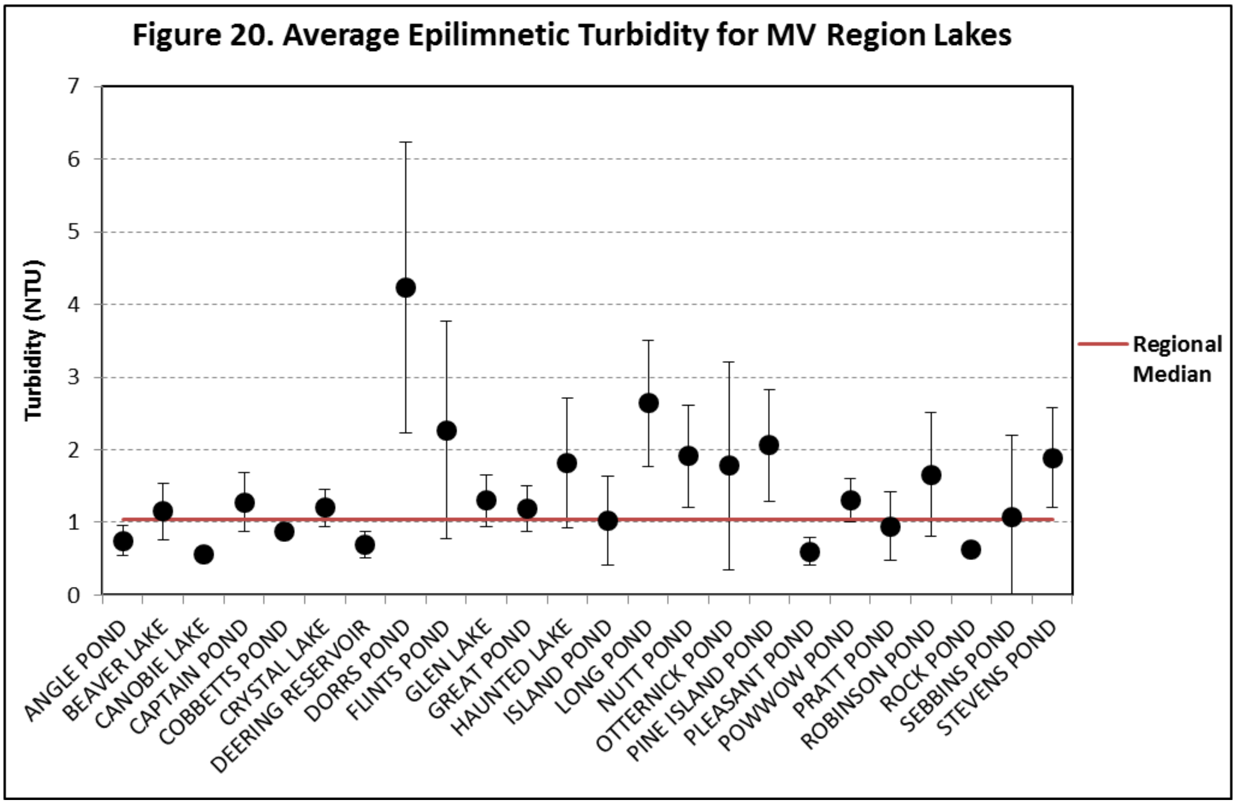
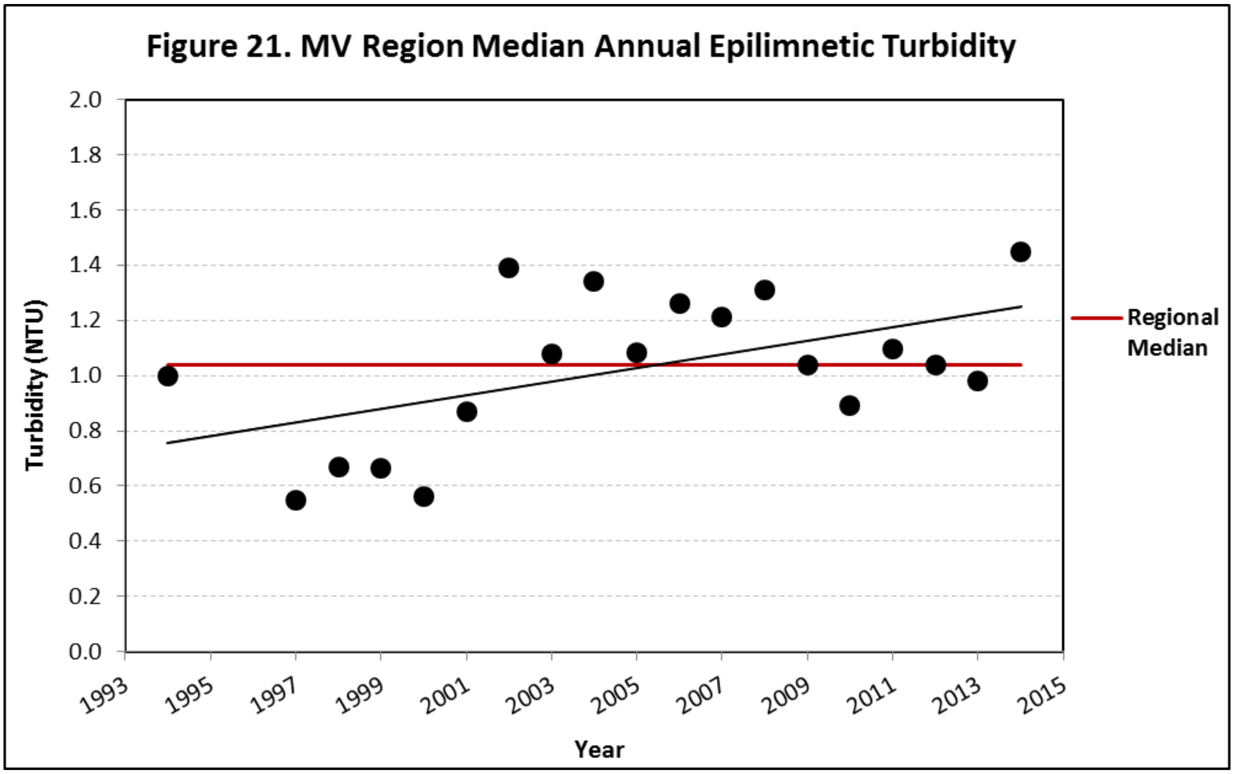


Figure 21 represents the median annual epilimnetic turbidity for the MV region. Medan epilimnetic turbidity generally remained between 0.5 and 0.7 NTUs from 1994 to 2000. Since then, median epilimnetic turbidity has remained between 0.8 and 1.4 NTUs. The 2014 median epilimnetic turbidity was 1.45 NTU, which is slightly above average for most lakes, and the highest median turbidity since monitoring began. New Hampshire has experienced more significant rainfall events in recent years which may be contributing to an increase in stormwater runoff and turbidity in the region's lakes.



Historical Turbidity Trend Analysis

The regional median epilimnetic turbidity was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significantly increasing (worsening) trend was detected for the MV region (Appendix D: Table D-1, Figure 21) which is consistent with all regions of the state.

Elevated deep spot turbidity levels are typically the result of stormwater runoff, algal or cyanobacteria blooms, and/or disturbance of lake bottom sediments. Stormwater BMPs should be implemented when possible to reduce the amount of suspended sediments and debris transported to surface water. Boating activity in shallow areas should adhere to rules specified by the New Hampshire Marine Patrol in regards to speed and no wake zones. If an algal or cyanobacteria bloom is observed, please contact NHDES immediately.

For additional information on stormwater BMPs, boating, algae and cyanobacteria, please refer to Appendices A and B.

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